TARDEC

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No. 13631

TARDEC

COMPUTER-BASED DYNAMIC AND FINITE ELEMENT ANALYSIS OF THE JOINT SERVICES IMAGERT PROCESSING SYSTEM (JSIPS) TRAILER; MODIFIED M371A1, 22-1/2-TON, FLATBED, SEMI-TRAILER

SEPTEMBER 1994

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This report describes the computer-based, dynamic and finite element analysis of the Joint Services Imagery Processing System (JSIPS) Trailer. The JSIPS trailer is a modified M871A1, 22-1/2-ton, flatbed, semi-trailer. The M871A1 deck and frame were converted from a flatbed configuration into a "gooseneck" configuration. The computer-based dynamic and finite element analysis was performed in order to determine what effects the modification would have on the structural integrity and/or operational performance of the trailer.

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1.0 SUMMARY

The System Simulation and Technology Division (AMSTA-RY), of the U.S. Army Tank-Automotive Research, Development, and Engineering Center (TARDEC) was tasked by the Product Manager, Trailers to perform a computer-based simulation of the M932A1, 6x6, 5-ton Semitractor, towing a Joint Services Imagery Processing System (JSIPS) trailer. The JSIPS trailer is an M871A1, 22-1/2-ton, flat bed, semitrailer that has been modified by converting the trailer deck and frame into a "gooseneck" configuration. PM, Trailers decided to use computer-based analyses to determine if the structural integrity and/or operational performance of the trailer would be degraded by these modifications. Computer-based analysis is an efficient, timely and cost-effective means of making such determinations.

Dynamic Analysis and Design System (DADS) software was used to create a three-dimensional, rigid-body model of the M932A1/JSIPS trailer system. This model served two purposes. The first was to simulate a series of driving maneuvers to test the stability of the truck/trailer system. The second purpose was to simulate the truck/trailer system encountering severe obstacles in order to induce dynamic forces into the structural members of the trailer frame. These forces, along with accelerations and displacements of various points on the trailer, were used as input for a finite element analysis of the structural integrity of the modified trailer frame. A detailed finite element model of the trailer frame was developed for this purpose.

The results of the analysis indicate that the modifications made to the M871A1 trailer do not degrade the dynamic performance or stability of the M932A1/JSIPS trailer system. The modifications should also not have a detrimental effect on the structural integrity of the system when performing its normal operating mission. However, it is recommended that extreme caution be used if forced to operate this system in a manner beyond its normal requirements.

2.0 INTRODUCTION/OBJECTIVE

2.1 Background

The System Simulation and Technology Division, of the U.S. Army Tank-Automotive Research, Development, and Engineering Center was tasked by the Product Manager, Trailers to perform a computer-based simulation of the M932A1, 6x6, 5-ton Semitractor, towing a Joint Services Imagery Processing System trailer. The JSIPS trailer is an M871A1, 22-1/2-ton, flat bed, Semi-Trailer that has been modified by converting the trailer deck and frame into a "gooseneck" configuration. The gooseneck was added to the trailer in order to raise the kingpin height of the trailer from 50 inches to 60 inches above the ground so that the trailer would be operational with the M931, M931A1, M932, and M932A1 tractors. The simulation included the

development and analysis of a full-scale dynamic model of the M932A1/JSIPS trailer combination and several finite element models of the JSIPS trailer frame. The dynamic model was used to determine if the change in kingpin height on the JSIPS trailer would have any detrimental effect on the stability and performance of the truck/trailer combination. The dynamic model was also used to generate a variety of reaction forces, displacements, and accelerations at the kingpin, support gussets, and trunnion attachment points. The reaction forces at these points were applied to the finite element models. Static-linear finite element analyses were run to determine the over-all structural integrity of the JSIPS semitrailer.

2.2 Analysis

A computer-based dynamic model of the M932A1/JSIPS trailer combination was created using Dynamic Analysis and Design System software. The DADS software is a set of general-purpose computer programs that can be used to model and predict the motion of a variety of vehicle systems. DADS builds a mathematical model of the vehicle system that calculates positions, velocities, and accelerations of the various parts of the system , as well as resultant forces that act within the system.

A finite element model and analysis of the trailer frame was also performed for this project. The finite element method is an analysis technique for solving the differential equations of complex problems. The method has become a valuable tool for modeling structural, mechanical, thermal, and fluid systems. In finite element analysis, a structure is broken down into simple discrete regions, or finite elements. These simple structural elements, which can be beams, shells, or solids, have elastic behavior that can be formulated mathematically. They are then assembled to form the overall structure of the item being analyzed. It is mandatory that the behavior of the model closely exhibits the behavior of the actual physical structure, in order to obtain realistic results and verify the model.

3.0 PROCEDURE

3.1 Dynamic Model

3.1.1 DADS Methodology

DADS contains a large library of mechanical elements that can be used to build a three-dimensional model of vehicle systems. These include rigid and flexible bodies, joints, constraints, force and torque-producing elements, as well as control and hydraulic elements.

Once a model has been defined from the library of 3-D elements, the data set is processed by the DADS analysis program and the model is mathematically assembled. The equations of motion for the various bodies in the model are

automatically generated and numerically solved. Results of the simulation are the positions, velocities, and accelerations of all bodies in the vehicle system. Also included are various data on any force elements in the model and the internal reaction forces due to any joints or constraints in the model.

A dynamic analysis was performed on the model of the M932A1/JSIPS trailer combination that was created for this project. In a dynamic analysis, the motion of the bodies is calculated from the forces acting upon them and the mass properties of the bodies themselves. These forces include gravity and any external forces specified by the user. The equations of motion are defined in terms of the masses and forces. The resulting second-order differential equations are then integrated numerically using a variable step and order algorithm.

3.1.2 M932A1/JSIPS Trailer Computer Model Description

A DADS, rev. 6.0, format file of the computer-based M932A1/JSIPS trailer model is shown in **Appendix A**. The M932A1 Tractor was modeled as rigid body. The leaf spring suspension was modeled as a series of translational spring damper actuators (TSDA) attaching the tractor body to the front and rear axles. The axle motion was constrained to allow only vertical translation and longitudinal rotation. A user-defined subroutine was used to calculate the individual spring displacements, roll stiffness, and the relative spring displacements in the rear bogey, where two axles share the same leaf spring. The trailer suspension was modeled similarly. The tractor/trailer 5th-wheel/kingpin interface was modeled as three revolute joints in order to limit the allowable pitch, roll, and yaw motion of the trailer at the interface. A user-defined subroutine was used to control the system's steering and velocity. The trailer was modeled as three rigid bodies (front deck, rear left deck, rear right deck) connected together at the gooseneck location with two bracket joints. Bracket joints remove the six degrees-of-freedom of one body relative to another. Using the bracket joints permitted the three rigid bodies to dynamically behave as one, but also permitted the recording of the reaction forces generated at the attachment points during the simulations. These reaction forces, along with those at the kingpin and trunnion attachment points, were used as the input loads for the finite element model of the trailer frame and gussets.

3.1.3 Simulations

TARDEC's Cray 2 super computer was use to run a series of dynamic simulations of the M932A1/JSIPS trailer performing the following:

1) Traversing a driver side, 6" bump, at 20 mph.
2) Traversing a driver side, 9" bump, at 5 mph.
3) Traversing a driver side, 9" bump, at 10 mph.
4) Traversing a driver side, 6" pothole, at 5 and 10 mph.

5) Traversing a driver side, 9" pothole, at 5 and 10 mph.
6) Traversing an alternating, 20% side slope course at 10 and 20 mph.
7) Performing a 120 ft X 11 ft, Slalom maneuver at 30 and 40 mph.
8) Traversing Belgian block at 20 mph.
9) Traversing Perryman Course # 1, unimproved cross-country, at 30 mph.

The cross country/Belgian block simulations were based on the requirements of MIL-M-8090F, Roadability Tests, para 4.5.12, Type V, group D mobility. The truck/trailer combination was simulated at the maximum allowable speeds for these test courses. MIL-M-8090F, TABLE III, requires Type V, group D vehicles to negotiate an 11.5-degree side slope. The combination was simulated running through a much more severe, alternating driver side and curb side, 20-degree side slope course. The slalom maneuver simulations were done to test the stability of the truck/trailer combination.

The bump and pothole simulations were done primarily to generate loading inputs for the finite element structural analysis of the JSIPS trailer gooseneck. The JSIPS trailer was modeled with a payload of 3,000 pounds on the forward portion of the deck and 22,000 pounds on the portion of the deck rearward from the gooseneck. This payload configuration was specified in paragraph 1 of the Purchase Description for the JSIPS trailer modifications.

3.2 Finite Element Models

3.2.1 Computer Hardware and Software

PATRAN is the pre/postprocessing software package used to visually create the finite element models (FEM). PATRAN's postprocessor allows the analyst to view the results of the analysis in graphical form. PATRAN version 3.0 was used on a Silicon Graphics Personal Iris workstation.

ABAQUS is a large-scale, general-purpose finite element analysis program capable of analyzing complex structures. ABAQUS was developed by Hibbitt, Karlsson, & Sorensen, Inc. ABAQUS version 5.2, which resides on TARDEC's Cray-2 Supercomputer, was used for this project.

3.2.2 Models

The finite element model contains all the information needed to run the analysis. The model defines the actual shape and dimensions of the trailer, the materials used and

their properties, and any boundary conditions and force loadings.

A beam finite element model of the entire JSIPS semitrailer frame was created for this project using PATRAN. The entire frame was modeled since the loads were not symmetric and there were no indicated areas of interest. The JSIPS FEM contains 354 elements and 535 nodes, giving 2,549 degrees of freedom (DOF). Two noded B31 beam elements and four/three noded S4R5/STR135 shell elements were used. There are 21 different beam cross-sectional properties which are defined in the ABAQUS 5.2 input file.

Items such as the payload and suspension are not physically modeled but were added to the FEM as mass loads. Also, items such as the spare tire and carrier, mud flaps, and hydraulic lines, which add no structural rigidity to the trailer, were not included in the FEM. A payload of 22,000 pounds was applied to the rear of the trailer and a 3,000-pound payload is over the front portion of the trailer.

3.2.3 Material Properties

The JSIPS semi-trailer is constructed primarily of ASTM A572 Grade 50 and ASTM A36 structural steel. The material properties are given in the table below.

Property	ASTM A572	ASTM A36
Young's Modulus	29.0×10^6 psi	29.0×10^6 psi
Density	0.284 lb/in^3	0.284 lb/in^3
Poisson's Ratio	0.30	0.30
Yield Strength*	50 ksi	36 ksi
Ultimate Strength*	65 ksi	58 ksi

* Minimum values listed

These material properties were used in the finite element analysis and the yield strength was used to quantify the results.

4.0 RESULTS and DISCUSSION

4.1 Dynamic Analysis

Appendix B (B-3 through B-15) contains the time history responses of the pitch, roll, and yaw angles of the JSIPS trailer frame for each of the simulations performed. The truck/trailer combination did not show any tendencies toward instability throughout the series of maneuvers simulated, as indicated by the plots. The most severe dynamic reaction of the JSIPS trailer occurred when responding to the 9-inch bump at the speeds of 5 and 10 mph (B-2,B-3). The trailer rolled to a maximum angle of

approximately 9.5° but returned to a stable condition. The side slope course simulations (B-8,B-9) show that the JSIPS trailer, as modeled, can sustain at least a 12.5° roll angle without overturning. The trailer did not show any unstable performance characteristics when performing the pothole (B-4 thru B-7), slalom (B-10,B-11), or cross-country (B-12,B-13) simulations.

Plots B-16 and B-17 show the time history response of the vertical accelerations (g's) into the trailer deck both fore and aft of the gooseneck for the Belgian block course and the Perryman Course #1 simulations respectively. These plots indicate a maximum vertical acceleration of approximately 1.25 g's into the forward deck, and approximately 1.5 g's into the rear deck during the Belgian block simulations. The maximum vertical accelerations for the Perryman 1 course simulations were under 1 g for both the forward and rear decks.

4.2 Finite Element Analysis

Several finite element analyses were run simulating different terrain and driving scenarios. Reaction forces, displacements, and accelerations were obtained from the dynamic simulations. These values, at specified time steps, were used in the static-linear finite element analyses. The time steps were picked based on maximum forces at the gussets or the suspension. For some analyses, multiple time steps were investigated in order to capture the "worst case" loads.

4.2.1 Failure Criterion

The Maximum Distortion Energy criterion was used to quantify the finite element analysis results for this project. According to this criterion, also known as the von Mises criterion, a given structural component is safe, as long as the maximum value of distortion energy per unit volume in that material remains smaller than the distortion energy per unit volume required to cause yield in a tensile test specimen of the same material. For this project, the von Mises stress, which also takes into account the shear effects, was compared to the yield strength of the material.

4.2.2 Simulations

9-inch bump at 10 mph: This was considered to be the worst case scenario the JSIPS trailer could possibly witness. The dynamic analysis simulates the truck/trailer going 10 mph while the left tires go over a 9 inch bump. The reaction forces in the gooseneck gusset area were highest at 4.257 seconds into the dynamic run. The reaction forces, accelerations, and displacements at this time step were used in the static finite element analysis. The resultant stresses were greater than the yield strength of the material, indicating plastic deformation. Under this condition, the trailer is unsafe and would fail, however, the extent of failure is unknown. The highest stress occurs in the outside gusset plate.

9-inch bump at 5 mph: The 9" bump dynamic simulation was run at a slower speed of 5 mph. A time step of 9.372 seconds was used. The stresses were in the same outside gusset plate location but were lower. The max von Mises stress was 32,900 psi which is below the yield strength of the material.

6-inch bump at 20 mph: For this analysis, two time steps were looked at, 2.277 and 2.739 seconds. For the 2.277-second case, the maximum von Mises stress was 45,200 psi and occurred in the outside gusset location. The gusset is constructed of ASTM A572 Grade 50 steel, which has a yield strength of 50 ksi. Figures 1 and 2 depict the color stress plot for this analysis. The second time step was 2.739 seconds. The maximum von Mises stress for this case was 32,900 psi, and occurred at a lateral C-channel crossmember near the suspension. This stress is also below the yield strength of the material, and is considered safe.

6-inch pothole at 5 mph: A time step of 8.778 seconds was used for this analysis. The stresses were well below the yield strength of the ASTM A572 material. The maximum von Mises stress was 27,900 psi and was in the outside gusset plate location.

Belgian Block at 20 mph: A time step of 7.557 seconds was used for this analysis. The maximum von Mises stress was 28,900 psi and was located in a lateral crossmember near the suspension of the trailer. This stress is well below the yield strength of the material, and is considered safe.

Perryman-1 at 30 mph: This analysis simulated a cross-country road with small hills. Two different time steps were investigated. The first was at 2.739 seconds into the dynamic analysis. The FEA results at this time show a maximum von Mises stress of 23,500 psi which is located on the outside gooseneck gusset plate. The second time step used was 5.445 seconds. The maximum stress was 26,200 psi and was located in the main center longitudinal rails, just rearward of the gooseneck. The stresses for both these analyses are below the yield strength of the steel.

5.0 CONCLUSIONS and RECOMMENDATIONS

5.1 Dynamic Analysis

The simulations performed for the dynamic analysis portion of this project were more severe than what the JSIPS trailer is likely to experience in actual use, due to its limited mission and the sensitivity of the electronic equipment it will transport. It should also be noted that the JSIPS trailer was modeled with a payload of 3,000 pounds on the forward portion of the deck and 22,000 pounds on the portion of the deck rearward from the gooseneck. These loads are greater than the payload data

provided by the Army Space Program Office. Based on the analysis performed, the modification of the M871A1 trailer will not have a detrimental effect on the overall stability or dynamic performance of the trailer.

5.2 Finite Element Analysis

The results of this report are based on a trailer in "like new" condition with no rust or other damage. Also, no fatigue analysis or prototype test were performed for this project.

The finite element analyses indicate no problems with the modified M871A1 trailer with one exception. The 9-inch bump at 10 mph simulation produced high stresses in the gooseneck region of the trailer that exceed the yield strength of the material. As mentioned previously, it is not likely that such a severe obstacle would be encountered during the normal mission of the JSIPS trailer. However, it is recommended that extreme caution be used when towing the JSIPS trailer through obstacles of this magnitude. For all other simulations, the stresses were below the material yield strength.

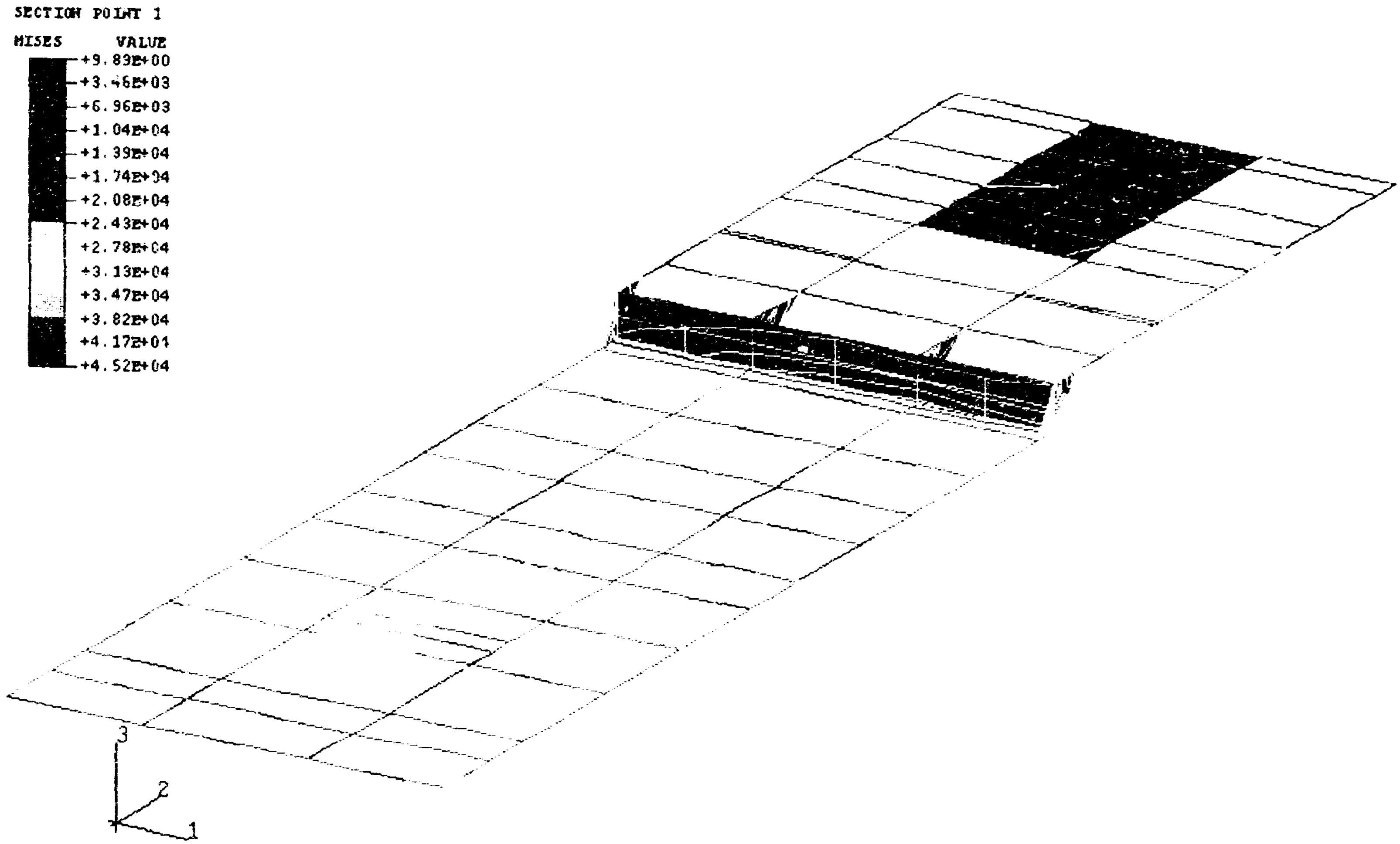


Figure 1. Finite Element Analysis Results for the JSIPS Trailer Frame Simulating a 6" bump at 20 mph at 2.277 seconds von Mises Stresses (psi)

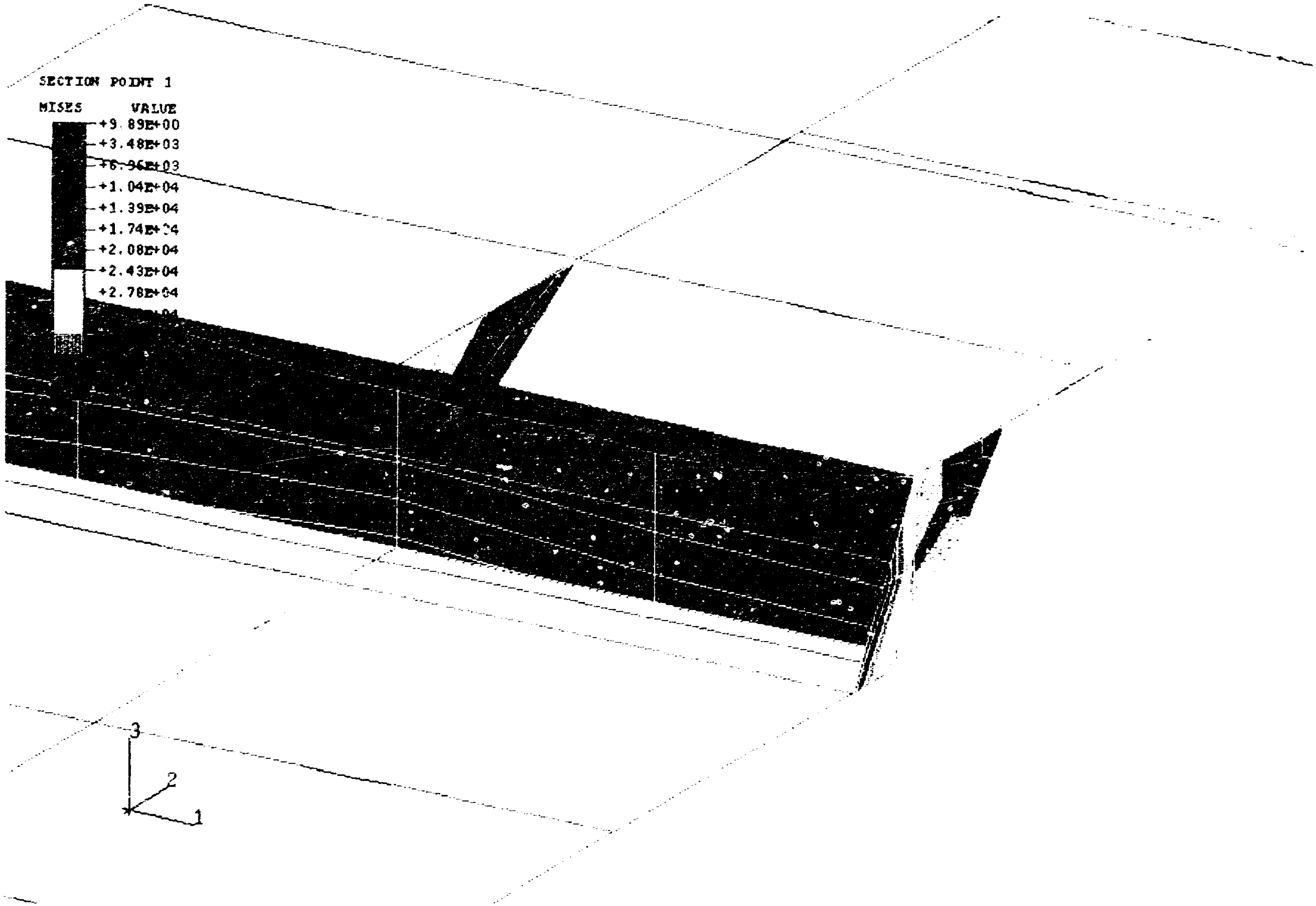
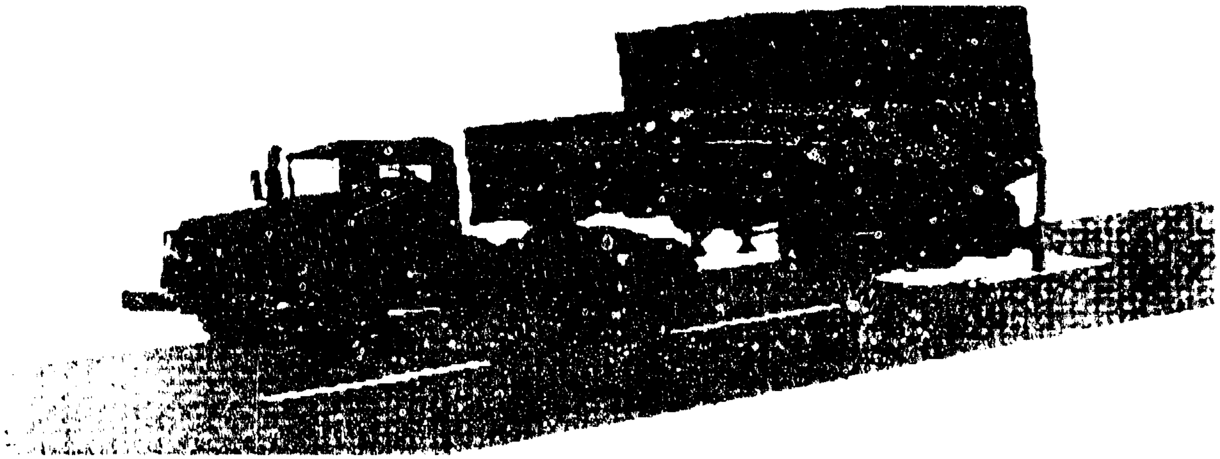
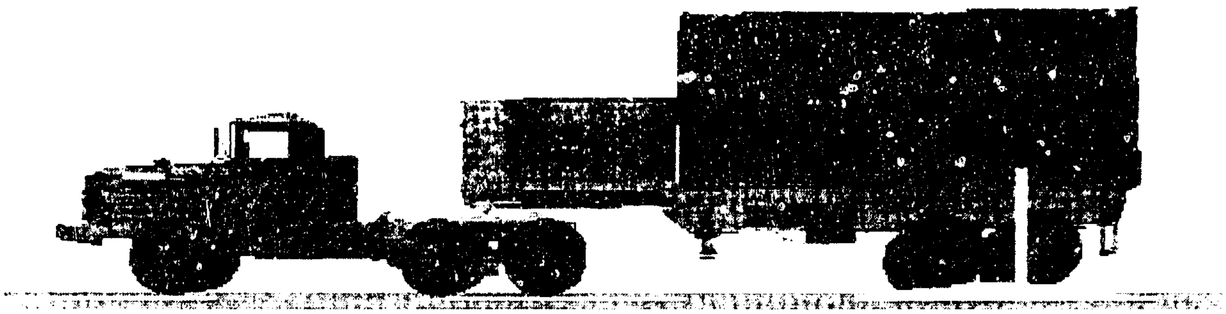


Figure 2. Finite Element Analysis Results for the JSIPS Trailer Frame
Simulating a 6" bump at 20 mph at 2.277 seconds
von Mises Stresses (psi)
(Close-up of Right, Outside Gusset Plate)



Front Left View



Side View

Rear Left View

Figure 3. M983/JSHPS Trailer Dynamic Model Simulating Traversal of a Bump at 20 mph

APPENDIX A

DADS Formatted File

```
*****************************************************************************
*****************************************************************************
**** M932A1 5-ton Semi-Tractor                                           ****
****                                                                     ****
**** Towing Modified M871 20 ton (JSIPS Trailer)                         ****
****                                                                     ****
**** The Payload consists of 22,000 lbs on the bed and 3,000 lbs on the  ****
**** gooseneck.                                                          ****
****                                                                     ****
**** Mike Pozolo 4/25/94                                                 ****
*****************************************************************************
*****************************************************************************

SYSTEM    INCHES              DYNAMIC                FULL      TRUE GLOBAL    TRUE
 386.08800000000     0.00000000000000E+000.00000000000000E+00-1.0000000000000
 1.0000000000000     0.00000000000000E+00 10.000000000000     0.33000000000000E-01
0.10000000000000E-110.10000000000000E-02FALSE      BINARY
DYNAMIC    TRUE       INTERPOLATED        GLOBAL
0.50000000000000E-010.10000000000000E-020.10000000000000E-03


*****************************************************************************
****                        FRONT AXLE
**** Front axle to chassis connection modelled as two distance constraints at
**** leaf spring location. One constraint in center of axle to center of chassis
**** to remove axle rotational degree of freedom. And one constraint extending
**** 100 inches out to the right side to remove lateral degree of freedom.
*****************************************************************************

**** constraints at leaf spring locations

DISTANCE  TA1WBL.DC            TCH.BOD             TA1.BOD                  0    0
-16.490000000000     24.250000000000      39.650000000000
-16.490000000000     0.00000000000000     22.500000000000
-16.490000000000     24.250000000000      40.650000000000
-16.490000000000     0.00000000000000     23.500000000000
-15.490000000000     24.250000000000      39.650000000000
-15.490000000000     0.00000000000000     22.500000000000
 29.701600000000
DISTANCE  TA1WBR.DC            TCH.BOD             TA1.BOD                  0    0
 16.490000000000     24.250000000000      39.650000000000
 16.490000000000     0.00000000000000     22.500000000000
 16.490000000000     24.250000000000      40.650000000000
 16.490000000000     0.00000000000000     23.500000000000
 17.490000000000     24.250000000000      39.650000000000
 17.490000000000     0.00000000000000     22.500000000000
 29.701600000000

**** constrains rotation of front axle

DISTANCE  TA1TR.DC             TCH.BOD             TA1.BOD                  0    0
 0.0000000000000     -24.250000000000     41.650000000000
 0.0000000000000     0.00000000000000     41.650000000000
 0.0000000000000     -24.250000000000     42.650000000000
 0.0000000000000     0.00000000000000     42.650000000000
 1.0000000000000     -24.250000000000     41.650000000000
 1.0000000000000     0.00000000000000     41.650000000000
 24.250000000000

**** tractor axle lateral constraint between front axle and chassis
```

```
DISTANCE  TA1PB.DC              TCH.BOD              TA1.BOD                     0    0
 100.0000000000     0.00000000000000    41.650000000000
0.00000000000000    0.00000000000000    41.650000000000
 100.0000000000     0.00000000000000    42.650000000000
0.00000000000000    0.00000000000000    42.650000000000
 101.0000000000     0.00000000000000    41.650000000000
 1.000000000000     0.00000000000000    41.650000000000
 100.0000000000

**** centerlink between front wheel steering knuckles

DISTANCE  TA1CL.DC              TA1LS.BOD            TA1RS.BOD                   0    0
-39.000000000000    -10.430000000000    16.310000000000
 39.000000000000    -10.430000000000    16.310000000000
-39.000000000000    -10.430000000000    17.310000000000
 39.000000000000    -10.430000000000    17.310000000000
-38.000000000000    -10.430000000000    16.310000000000
 40.000000000000    -10.430000000000    16.310000000000
 78.000000000000


*****               END of FRONT AXLE
********************************************************************************


********************************************************************************
****                    REAR AXLES
**** Rear axle to chassis connection modelled as two distance constraints at
**** leaf spring locations. Actual suspension has two lower suspension
**** members on each side of leaf spring mount to the center beam.
**** It also has a single suspension member above the axle.  With this
**** suspension configuration, an extra lateral constraint must be added
**** to remove the extra lateral degree of freedom.
********************************************************************************

**** constraints at leaf spring locations

DISTANCE  TA2WBL.DC             TCH.BOD              TA2.BOD                     0    0
-18.690000000000    -163.68000000000    12.670000000000
-18.690000000000    -140.00000000000    13.560000000000
-18.690000000000    -163.68000000000    13.670000000000
-18.690000000000    -140.00000000000    14.560000000000
-17.690000000000    -163.68000000000    12.670000000000
-17.690000000000    -140.00000000000    13.560000000000
 23.696700000000
DISTANCE  TA3WBL.DC             TCH.BOD              TA3.BOD                     0    0
-18.690000000000    -170.32000000000    12.670000000000
-18.690000000000    -194.00000000000    13.560000000000
-18.690000000000    -170.32000000000    13.670000000000
-18.690000000000    -194.00000000000    14.560000000000
-17.690000000000    -170.32000000000    12.670000000000
-17.690000000000    -194.00000000000    13.560000000000
 23.696700000000
DISTANCE  TA2WBR.DC             TCH.BOD              TA2.BOD                     0    0
 18.690000000000    -163.68000000000    12.670000000000
 18.690000000000    -140.00000000000    13.560000000000
 18.690000000000    -163.68000000000    13.670000000000
 18.690000000000    -140.00000000000    14.560000000000
 17.690000000000    -163.68000000000    12.670000000000
```

```
 17.690000000000     -140.00000000000      13.560000000000
 23.696700000000
DISTANCE  TA3WBR.DC               TCH.BOD               TA3.BOD                   0     0
 18.690000000000     -170.32000000000      12.670000000000
 18.690000000000     -194.00000000000      13.560000000000
 18.690000000000     -170.32000000000      13.670000000000
 18.690000000000     -194.00000000000      14.560000000000
 17.690000000000     -170.32000000000      12.670000000000
 17.690000000000     -194.00000000000      13.560000000000
 23.696700000000

***** rear suspension arrangement to control lateral motion

DISTANCE  TA2TR.DC                TCH.BOD               TA2.BOD                   0     0
-22.640000000000     -166.00000000000      41.470000000000
-22.640000000000     -140.00000000000      41.470000000000
-22.640000000000     -166.00000000000      40.470000000000
-22.640000000000     -140.00000000000      40.470000000000
-21.640000000000     -166.00000000000      41.470000000000
-21.640000000000     -140.00000000000      41.470000000000
 26.000000000000
DISTANCE  TA3TR.DC                TCH.BOD               TA3.BOD                   0     0
-22.640000000000     -168.00000000000      41.470000000000
-22.640000000000     -194.00000000000      41.470000000000
-22.640000000000     -168.00000000000      40.470000000000
-22.640000000000     -194.00000000000      40.470000000000
-21.640000000000     -168.00000000000      41.470000000000
-21.640000000000     -194.00000000000      41.470000000000
 26.000000000000
DISTANCE  TA2PB.DC                TCH.BOD               TA2.BOD                   0     0
 100.00000000000     -140.00000000000      40.260000000000
 0.000000000000      -140.00000000000      40.260000000000
 100.00000000000     -140.00000000000      41.260000000000
 0.000000000000      -140.00000000000      41.260000000000
 101.00000000000     -140.00000000000      40.260000000000
 1.000000000000      -140.00000000000      40.260000000000
 100.00000000000
DISTANCE  TA3PB.DC                TCH.BOD               TA3.BOD                   0     0
 100.00000000000     -194.00000000000      40.260000000000
 0.000000000000      -194.00000000000      40.260000000000
 100.00000000000     -194.00000000000      41.260000000000
 0.000000000000      -194.00000000000      41.260000000000
 101.00000000000     -194.00000000000      40.260000000000
 1.000000000000      -194.00000000000      40.260000000000
 100.00000000000

*****                END of REAR AXLES
*********************************************************************************

***** Curves to include bump steer effects ufrc11.f uses RSDA #1,2 to steering.

RSDA      TA1LSBS.RSDA        TA1LKP.REV
TSBSL.CUR            NONE                  NONE
0.0000000000000      0.0000000000000       0.0000000000000       0.0000000000000
RSDA      TA1RSBS.RSDA        TA1RKP.REV
TSBSR.CUR            NONE                  NONE
0.0000000000000      0.0000000000000       0.0000000000000       0.0000000000000

**** M932A1 Super Singles, 14R20, LOAD J, Ply Rating 18, All-Terrain
```

```
TIRE        TA1L.TIRE               TA1LW.BOD               TA1LS.BOD               FULL
TIRELS.CUR               NONE                    NONE                    NONE
-39.000000000000         0.00000000000000        22.670000000000
 24.450000000000         0.00000000000000        8.0000000000000
3500.00000000000          108861.98107486        0.00000000000000
0.80000000000000
TIRE        TA1R.TIRE               TA1RW.BOD               TA1RS.BOD               FULL
TIRELS.CUR               NONE                    NONE                    NONE
 39.000000000000         0.00000000000000        22.670000000000
 24.450000000000         0.00000000000000        8.0000000000000
3500.00000000000          108861.98107486        0.00000000000000
0.80000000000000
TIRE        TA2L.TIRE               TA2LW.BOD               TA2.BOD                 FULL
TIRELS.CUR               NONE                    NONE                    NONE
-40.656250000000         -140.00000000000        22.670000000000
 24.450000000000         0.00000000000000        8.0000000000000
3500.00000000000          108861.98107486        0.00000000000000
0.80000000000000
TIRE        TA2R.TIRE               TA2RW.BOD               TA2.BOD                 FULL
TIRELS.CUR               NONE                    NONE                    NONE
 40.656250000000         -140.00000000000        22.670000000000
 24.450000000000         0.00000000000000        8.0000000000000
3500.00000000000          108861.98107486        0.00000000000000
0.80000000000000
TIRE        TA3L.TIRE               TA3LW.BOD               TA3.BOD                 FULL
TIRELS.CUR               NONE                    NONE                    NONE
-40.656250000000         -194.00000000000        22.670000000000
 24.450000000000         0.00000000000000        8.0000000000000
3500.00000000000          108861.98107486        0.00000000000000
0.80000000000000
TIRE        TA3R.TIRE               TA3RW.BOD               TA3.BOD                 FULL
TIRELS.CUR               NONE                    NONE                    NONE
 40.656250000000         -194.00000000000        22.670000000000
 24.450000000000         0.00000000000000        8.0000000000000
3500.00000000000          108861.98107486        0.00000000000000
0.80000000000000

**** Tractor springs controlled from ufrc10.f
**** First group of 6 TSDAs used to measure relative distance between right
**** and left spring displacements on common axles and to average the
**** displacement of the rear springs which share the same axle.

TSDA        TA1LSPR.TSDA        TCH.BOD                 TA1.BOD                          0     0
NONE                     NONE                    NONE
-16.490000000000         0.00000000000000        122.50000000000
-16.490000000000         0.00000000000000        22.500000000000
-16.490000000000         0.00000000000000        123.45000000000
-16.490000000000         0.00000000000000        23.450000000000
-15.490000000000         0.00000000000000        122.50000000000
-15.490000000000         0.00000000000000        22.500000000000
0.00000000000000          100.00000000000        0.00000000000000        0.00000000000000
TSDA        TA2LSPR.TSDA        TCH.BOD                 TA2.BOD                          0     0
NONE                     NONE                    NONE
-18.690000000000         -140.00000000000        122.50000000000
-18.690000000000         -140.00000000000        22.500000000000
-18.690000000000         -140.00000000000        123.45000000000
-18.690000000000         -140.00000000000        23.450000000000
-17.690000000000         -140.00000000000        122.50000000000
-17.690000000000         -140.00000000000        22.500000000000
0.00000000000000          100.00000000000        10.000000000000         0.00000000000000
```

```
TSDA        TA3LSPR.TSDA          TCH.BOD                     TA3.BOD                      0     0
NONE                    NONE                    NONE
-18.690000000000        -194.00000000000         122.50000000000
-18.690000000000        -194.00000000000         22.500000000000
-18.690000000000        -194.00000000000         123.45000000000
-18.690000000000        -194.00000000000         23.450000000000
-17.690000000000        -194.00000000000         122.50000000000
-17.690000000000        -194.00000000000         22.500000000000
0.00000000000000         100.00000000000        10.000000000000        0.00000000000000
TSDA        TA1RSPR.TSDA          TCH.BOD                     TA1.BOD                      0     0
NONE                    NONE                    NONE
 16.490000000000        0.00000000000000         122.50000000000
 16.490000000000        0.00000000000000         22.500000000000
 16.490000000000        0.00000000000000         123.45000000000
 16.490000000000        0.00000000000000         23.450000000000
 15.490000000000        0.00000000000000         122.50000000000
 15.490000000000        0.00000000000000         22.500000000000
0.00000000000000         100.00000000000        0.00000000000000       0.00000000000000
TSDA        TA2RSPR.TSDA          TCH.BOD                     TA2.BOD                      0     0
NONE                    NONE                    NONE
 18.690000000000        -140.00000000000         122.50000000000
 18.690000000000        -140.00000000000         22.500000000000
 18.690000000000        -140.00000000000         123.45000000000
 18.690000000000        -140.00000000000         23.450000000000
 17.690000000000        -140.00000000000         122.50000000000
 17.690000000000        -140.00000000000         22.500000000000
0.00000000000000         100.00000000000        10.000000000000        0.00000000000000
TSDA        TA3RSPR.TSDA          TCH.BOD                     TA3.BOD                      0     0
NONE                    NONE                    NONE
 18.690000000000        -194.00000000000         122.50000000000
 18.690000000000        -194.00000000000         22.500000000000
 18.690000000000        -194.00000000000         123.45000000000
 18.690000000000        -194.00000000000         23.450000000000
 17.690000000000        -194.00000000000         122.50000000000
 17.690000000000        -194.00000000000         22.500000000000
0.00000000000000         100.00000000000        10.000000000000        0.00000000000000

**** Spring forces applied by second group of 6 TSDAs

TSDA        TA1LSP.TSDA           TCH.BOD                     TA1.BOD                      0     0
TBSTOP.CUR              NONE                    NONE
-16.490000000000        0.00000000000000         122.50000000000
-16.490000000000        0.00000000000000         22.500000000000
-16.490000000000        0.00000000000000         123.45000000000
-16.490000000000        0.00000000000000         23.450000000000
-15.490000000000        0.00000000000000         122.50000000000
-15.490000000000        0.00000000000000         22.500000000000
2271.0000000000         100.000000000000        0.00000000000000       0.00000000000000
TSDA        TA2LSP.TSDA           TCH.BOD                     TA2.BOD                      0     0
TBSTOP.CUR              NONE                    NONE
-18.690000000000        -140.00000000000         122.50000000000
-18.690000000000        -140.00000000000         22.500000000000
-18.690000000000        -140.00000000000         123.45000000000
-18.690000000000        -140.00000000000         23.450000000000
-17.690000000000        -140.00000000000         122.50000000000
-17.690000000000        -140.00000000000         22.500000000000
5983.0000000000         100.000000000000        10.000000000000        0.00000000000000
TSDA        TA3LSP.TSDA           TCH.BOD                     TA3.BOD                      0     0
TBSTOP.CUR              NONE                    NONE
-18.690000000000        -194.00000000000         122.50000000000
```

```
-18.690000000000    -194.00000000000    22.500000000000
-18.690000000000    -194.00000000000    123.45000000000
-18.690000000000    -194.00000000000    23.450000000000
-17.690000000000    -194.00000000000    122.50000000000
-17.690000000000    -194.00000000000    22.500000000000
5983.00000000000    100.000000000000    10.0000000000000    0.00000000000000
TSDA       TA1RSP.TSDA          TCH.BOD              TA1.BOD              0    0
TBSTOP.CUR          NONE                NONE
 16.490000000000    0.00000000000000    122.50000000000
 16.490000000000    0.00000000000000    22.500000000000
 16.490000000000    0.00000000000000    123.45000000000
 16.490000000000    0.00000000000000    23.450000000000
 15.490000000000    0.00000000000000    122.50000000000
 15.490000000000    0.00000000000000    22.500000000000
2271.00000000000    100.000000000000    0.00000000000000    0.00000000000000
TSDA       TA2RSP.TSDA          TCh.BOD              TA2.BOD              0    0
TBSTOP.CUR          NONE                NONE
 18.690000000000    -140.00000000000    122.50000000000
 18.690000000000    -140.00000000000    22.500000000000
 18.690000000000    -140.00000000000    123.45000000000
 18.690000000000    -140.00000000000    23.450000000000
 17.690000000000    -140.00000000000    122.50000000000
 17.690000000000    -140.00000000000    22.500000000000
5983.00000000000    100.000000000000    10.0000000000000    0.00000000000000
TSDA       TA3RSP.TSDA          TCH.BOD              TA3.BOD              0    0
TBSTOP.CUR          NONE                NONE
 18.690000000000    -194.00000000000    122.50000000000
 18.690000000000    -194.00000000000    22.500000000000
 18.690000000000    -194.00000000000    123.45000000000
 18.690000000000    -194.00000000000    23.450000000000
 17.690000000000    -194.00000000000    122.50000000000
 17.690000000000    -194.00000000000    22.500000000000
5983.00000000000    100.000000000000    10.0000000000000    0.00000000000000

REVOLUTE  TA1LKP.REV            TA1.BOD              TA1LS.BOD            0    0
-39.000000000000    0.00000000000000    22.670000000000
-39.000000000000    0.00000000000000    22.670000000000
-39.000000000000    0.00000000000000    23.670000000000
-39.000000000000    0.00000000000000    23.670000000000
-38.000000000000    0.00000000000000    22.670000000000
-38.000000000000    0.00000000000000    22.670000000000
REVOLUTE  TA1RKP.REV            TA1.BOD              TA1RS.BOD            0    0
 39.000000000000    0.00000000000000    22.670000000000
 39.000000000000    0.00000000000000    22.670000000000
 39.000000000000    0.00000000000000    23.670000000000
 39.000000000000    0.00000000000000    23.670000000000
 40.000000000000    0.00000000000000    22.670000000000
 40.000000000000    0.00000000000000    22.670000000000


**** tractor axle to wheel revolute joints

REVOLUTE  TA1LW.REV             TA1LS.BOD            TA1LW.BOD            0    0
-39.000000000000    0.00000000000000    22.670000000000
-39.000000000000    0.00000000000000    22.670000000000
-38.000000000000    0.00000000000000    22.670000000000
-38.000000000000    0.00000000000000    22.670000000000
-39.000000000000    0.00000000000000    23.670000000000
-39.000000000000    0.00000000000000    23.670000000000
REVOLUTE  TA1RW.REV             TA1RS.BOD            TA1RW.BOD            0    0
```

```
 39.000000000000    0.00000000000000     22.670000000000
 39.000000000000    0.00000000000000     22.670000000000
 40.000000000000    0.00000000000000     22.670000000000
 40.000000000000    0.00000000000000     22.670000000000
 39.000000000000    0.00000000000000     23.670000000000
 39.000000000000    0.00000000000000     23.670000000000
REVOLUTE  TA2LW.REV           TA2.BOD              TA2LW.BOD             0    0
-39.000000000000    -140.00000000000     22.670000000000
-39.000000000000    -140.00000000000     22.670000000000
-38.000000000000    -140.00000000000     22.670000000000
-38.000000000000    -140.00000000000     22.670000000000
-39.000000000000    -140.00000000000     23.670000000000
-39.000000000000    -140.00000000000     23.670000000000
REVOLUTE  TA2RW.REV           TA2.BOD              TA2RW.BOD             0    0
 39.000000000000    -140.00000000000     22.670000000000
 39.000000000000    -140.00000000000     22.670000000000
 40.000000000000    -140.00000000000     22.670000000000
 40.000000000000    -140.00000000000     22.670000000000
 39.000000000000    -140.00000000000     23.670000000000
 39.000000000000    -140.00000000000     23.670000000000
REVOLUTE  TA3LW.REV           TA3.BOD              TA3LW.BOD             0    0
-39.000000000000    -194.00000000000     22.670000000000
-39.000000000000    -194.00000000000     22.670000000000
-38.000000000000    -194.00000000000     22.670000000000
-38.000000000000    -194.00000000000     22.670000000000
-39.000000000000    -194.00000000000     23.670000000000
-39.000000000000    -194.00000000000     23.670000000000
REVOLUTE  TA3RW.REV           TA3.BOD              TA3RW.BOD             0    0
 39.000000000000    -194.00000000000     22.670000000000
 39.000000000000    -194.00000000000     22.670000000000
 40.000000000000    -194.00000000000     22.670000000000
 40.000000000000    -194.00000000000     22.670000000000
 39.000000000000    -194.00000000000     23.670000000000
 39.000000000000    -194.00000000000     23.670000000000

**** model of the 5th wheel hitch point

REVOLUTE  HITCH_1             HITCH1.BOD           TCH.BOD               0    0
0.00000000000000    -162.81000000000     47.620000000000
0.00000000000000    -162.81000000000     47.620000000000
1.00000000000000    -162.81000000000     47.620000000000
1.00000000000000    -162.81000000000     47.620000000000
0.00000000000000    -162.81000000000     48.620000000000
0.00000000000000    -162.81000000000     48.620000000000
REVOLUTE  HITCH_2             HITCH1.BOD           HITCH2.BOD            0    0
0.00000000000000    -162.81000000000     57.187500000000
0.00000000000000    -162.81000000000     57.187500000000
0.00000000000000    -161.81000000000     57.187500000000
0.00000000000000    -161.81000000000     57.187500000000
1.00000000000000    -162.81000000000     57.187500000000
1.00000000000000    -162.81000000000     57.187500000000
REVOLUTE  HITCH_3             HITCH2.BOD           F_DECK.BOD            0    0
0.00000000000000    -162.81000000000     57.187500000000
0.00000000000000    -162.81000000000     57.187500000000
0.00000000000000    -162.81000000000     58.187500000000
0.00000000000000    -162.81000000000     58.187500000000
1.00000000000000    -162.81000000000     57.187500000000
1.00000000000000    -162.81000000000     57.187500000000

RSDA      HITCH_ROLL          HITCH_2
```

```
BLOCKS_IN                  NONE                       NONE
0.00000000000000           0.00000000000000           0.00000000000000           0.00000000000000

**** tractor body # 1 Path control frc11.f uses the body location to find path

BODY         TCH.BOD                    POSITIVE      PARAMETERSFALSEFALSEFALSE
NONE                       NONE                       NONE
NONE                       NONE                       NONE
0.00000000000000           -117.50000000000           37.700000000000
0.00000000000000           0.00000000000000           0.00000000000000
 29.466200000000            175998.39510000            15889.746100000           175998.39510000
0.00000000000000           0.00000000000000           0.00000000000000
0.00000000000000           0.00000000000000           0.00000000000000
0.00000000000000           0.00000000000000           0.00000000000000

**** tractor axles

BODY         TA1.BOD                    POSITIVE      PARAMETERSFALSEFALSEFALSE
NONE                       NONE                       NONE
NONE                       NONE                       NONE
0.00000000000000           0.00000000000000            22.670000000000
0.00000000000000           0.00000000000000           0.00000000000000
 6.7614000000000            3600.0000000000            2400.0000000000           3600.0000000000
0.00000000000000           0.00000000000000           0.00000000000000
0.00000000000000           0.00000000000000           0.00000000000000
0.00000000000000           0.00000000000000           0.00000000000000
BODY         TA2.BOD                    POSITIVE      PARAMETERSFALSEFALSEFALSE
NONE                       NONE                       NONE
NONE                       NONE                       NONE
0.00000000000000           -140.00000000000            22.670000000000
0.00000000000000           0.00000000000000           0.00000000000000
 7.0120000000000            3600.0000000000            2400.0000000000           2400.0000000000
0.00000000000000           0.00000000000000           0.00000000000000
0.00000000000000           0.00000000000000           0.00000000000000
0.00000000000000           0.00000000000000           0.00000000000000
BODY         TA3.BOD                    POSITIVE      PARAMETERSFALSEFALSEFALSE
NONE                       NONE                       NONE
NONE                       NONE                       NONE
0.00000000000000           -194.00000000000            22.670000000000
0.00000000000000           0.00000000000000           0.00000000000000
 7.2710000000000            3600.0000000000            2400.0000000000           2400.0000000000
0.00000000000000           0.00000000000000           0.00000000000000
0.00000000000000           0.00000000000000           0.00000000000000
0.00000000000000           0.00000000000000           0.00000000000000

**** steering knuckles

BODY         TA1LS.BOD                  POSITIVE      PARAMETERSFALSEFALSEFALSE
NONE                       NONE                       NONE
NONE                       NONE                       NONE
-39.000000000000           0.00000000000000            22.670000000000
0.00000000000000           0.00000000000000           0.00000000000000
0.10000000000000E-01 1.0000000000000                   1.0000000000000           1.0000000000000
0.00000000000000           0.00000000000000           0.00000000000000
0.00000000000000           0.00000000000000           0.00000000000000
0.00000000000000           0.00000000000000           0.00000000000000
BODY         TA1RS.BOD                  POSITIVE      PARAMETERSFALSEFALSEFALSE
NONE                       NONE                       NONE
NONE                       NONE                       NONE
 39.000000000000           0.00000000000000            22.670000000000
```

```
0.00000000000000     0.00000000000000     0.00000000000000
0.10000000000000E-01 1.0000000000000      1.0000000000000      1.0000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000

**** tractor wheels

BODY      TA1LW.BOD            POSITIVE  PARAMETERSFALSEFALSEFALSE
NONE                 NONE                 NONE
NONE                 NONE                 NONE
-39.000000000000     0.00000000000000     22.670000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.89000000000000      225.00000000000     133.00000000000      133.00000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
BODY      TA1RW.BOD            POSITIVE  PARAMETERSFALSEFALSEFALSE
NONE                 NONE                 NONE
NONE                 NONE                 NONE
 39.000000000000     0.00000000000000     22.670000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.89000000000000      225.00000000000     133.00000000000      133.00000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
BODY      TA2LW.BOD            POSITIVE  PARAMETERSFALSEFALSEFALSE
NONE                 NONE                 NONE
NONE                 NONE                 NONE
-40.656250000000     -140.00000000000     22.670000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.89000000000000      225.00000000000     133.00000000000      133.00000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
BODY      TA2RW.BOD            POSITIVE  PARAMETERSFALSEFALSEFALSE
NONE                 NONE                 NONE
NONE                 NONE                 NONE
 40.656250000000     -140.00000000000     22.670000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.89000000000000      225.00000000000     133.00000000000      133.00000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
BODY      TA3LW.BOD            POSITIVE  PARAMETERSFALSEFALSEFALSE
NONE                 NONE                 NONE
NONE                 NONE                 NONE
-40.656250000000     -194.00000000000     22.670000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.89000000000000      225.00000000000     133.00000000000      133.00000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
BODY      TA3RW.BOD            POSITIVE  PARAMETFRSFALSEFALSEFALSE
NONE                 NONE                 NONE
NONE                 NONE                 NONE
 40.656250000000     -194.00000000000     22.670000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.89000000000000      225.00000000000     133.00000000000      133.00000000000
0.00000000000000     0.00000000000000     0.00000000000000
```

```
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000

**** 5th wheel hitch bodies

BODY      HITCH1.BOD           POSITIVE   PARAMETERSFALSEFALSEFALSE
NONE                 NONE                 NONE
NONE                 NONE                 NONE
 0.0000000000000     -162.81000000000     47.620000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.26000000000000      1.0000000000000      1.0000000000000     1.0000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
BODY      HITCH2.BOD           POSITIVE   PARAMETERSFALSEFALSEFALSE
NONE                 NONE                 NONE
NONE                 NONE                 NONE
 0.0000000000000     -162.81000000000     57.187500000000
0.00000000000000     0.00000000000000     0.00000000000000
0.26000000000000      1.0000000000000      1.0000000000000     1.0000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000

**** Intial conditions on tractor

INITIAL   TCHO.IC              TCH.BOD              NONE
NONE                 ORIENTATION            0
0.00000000000000     0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
INITIAL   TCHX.IC              TCH.BOD              NONE
NONE                 X                      0
0.00000000000000     0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
INITIAL   TCHY.IC              TCH.BOD              NONE
NONE                 Y                      0
0.00000000000000     352.000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
INITIAL   TCHZ.IC              TCH.BOD              NONE
NONE                 Z                      0
0.00000000000000     0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
INITIAL   TA1Z.IC              TA1.BOD              NONE
NONE                 Z                      0
0.00000000000000     0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
INITIAL   TA2Z.IC              TA2.BOD              NONE
NONE                 Z                      0
0.00000000000000     0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
INITIAL   TA3Z.IC              TA3.BOD              NONE
NONE                 Z                      0
0.00000000000000     0.00000000000000     0.00000000000000     0.00000000000000
0.00000000000000     0.00000000000000     0.00000000000000
```

0.0000000000000	0.0000000000000	0.0000000000000	
INITIAL TA1E2.IC	TA1.BOD	NONE	
NONE	E2	0	
0.0000000000000	0.0000000000000	0.0000000000000	0.0000000000000
0.0000000000000	0.0000000000000	0.0000000000000	
0.0000000000000	0.0000000000000	0.0000000000000	
INITIAL TA2E2.IC	TA2.BOD	NONE	
NONE	E2	0	
0.0000000000000	0.0000000000000	0.0000000000000	0.0000000000000
0.0000000000000	0.0000000000000	0.0000000000000	
0.0000000000000	0.0000000000000	0.0000000000000	
INITIAL TA3E2.IC	TA3.BOD	NONE	
NONE	E2	0	
0.0000000000000	0.0000000000000	0.0000000000000	0.0000000000000
0.0000000000000	0.0000000000000	0.0000000000000	
0.0000000000000	0.0000000000000	0.0000000000000	
INITIAL TA1LW.IC	TA1LW.BOD	NONE	
NONE	E1	0	
0.0000000000000	0.0000000000000	0.0000000000000	0.0000000000000
0.0000000000000	0.0000000000000	0.0000000000000	
0.0000000000000	0.0000000000000	0.0000000000000	
INITIAL TA1RW.IC	TA1RW.BOD	NONE	
NONE	E1	0	
0.0000000000000	0.0000000000000	0.0000000000000	0.0000000000000
0.0000000000000	0.0000000000000	0.0000000000000	
0.0000000000000	0.0000000000000	0.0000000000000	
INITIAL TA2LW.IC	TA2LW.BOD	NONE	
NONE	E1	0	
0.0000000000000	0.0000000000000	0.0000000000000	0.0000000000000
0.0000000000000	0.0000000000000	0.0000000000000	
0.0000000000000	0.0000000000000	0.0000000000000	
INITIAL TA2RW.IC	TA2RW.BOD	NONE	
NONE	E1	0	
0.0000000000000	0.0000000000000	0.0000000000000	0.0000000000000
0.0000000000000	0.0000000000000	0.0000000000000	
0.0000000000000	0.0000000000000	0.0000000000000	
INITIAL TA3LW.IC	TA3LW.BOD	NONE	
NONE	E1	0	
0.0000000000000	0.0000000000000	0.0000000000000	0.0000000000000
0.0000000000000	0.0000000000000	0.0000000000000	
0.0000000000000	0.0000000000000	0.0000000000000	
INITIAL TA3RW.IC	TA3RW.BOD	NONE	
NONE	E1	0	
0.0000000000000	0.0000000000000	0.0000000000000	0.0000000000000
0.0000000000000	0.0000000000000	0.0000000000000	
0.0000000000000	0.0000000000000	0.0000000000000	
INITIAL TA1LS.IC	TA1LS.BOD	NONE	
NONE	E3	0	
0.0000000000000	0.0000000000000	0.0000000000000	0.0000000000000
0.0000000000000	0.0000000000000	0.0000000000000	
0.0000000000000	0.0000000000000	0.0000000000000	
INITIAL TA1RS.IC	TA1RS.BOD	NONE	
NONE	E3	0	
0.0000000000000	0.0000000000000	0.0000000000000	0.0000000000000
0.0000000000000	0.0000000000000	0.0000000000000	
0.0000000000000	0.0000000000000	0.0000000000000	
INITIAL HITCH1.IC	HITCH1.BOD	NONE	
NONE	E1	0	
0.0000000000000	0.0000000000000	0.0000000000000	0.0000000000000
0.0000000000000	0.0000000000000	0.0000000000000	

```
0.00000000000000     0.00000000000000     0.00000000000000
********************************************************************************
********************************************************************************
********************************************************************************
*****************   JSIPS TRAILER;  Modified M871    ****************************
********************************************************************************
********************************************************************************
********************************************************************************

**** Rear suspension is a walking beam style with no torque rods, only the
**** spring resists brake torques
**** Each side of the suspension is modeled as axles connnected to a center
**** body. This body in turn is connected to the chassis by revolute joints
**** at the axle trunnion. This is an approximation of trying to simulate
**** the behavior of the leaf spring.
****
****                    center body
****
****       &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&
****                        &&&
****         |              &&&                |
****         |              &&&                |
****         |  TSDA        &&&                |  TSDA
****         |              &&&                |
****         |              &&&                |
****            distance    &&&  constraints
****         * ------------ && && ---------- *
****  axle  ***             &&   &&         ***  axle2
****         * ------------ && && ---------- *
****
****                      trunnion
****
********************************************************************************

*** trailer lateral constraint for axles

DISTANCE  TFAXLE_LAT           RR_DECK.BOD         TFAXLE                        0     0
 500.00000000000      -401.81000000000     20.500000000000
0.00000000000000      -401.81000000000     20.500000000000
 500.00000000000      -400.81000000000     20.500000000000
0.00000000000000      -400.81000000000     20.500000000000
 500.00000000000      -401.81000000000     21.500000000000
0.00000000000000      -401.81000000000     21.500000000000
 500.00000000000
DISTANCE  TRAXLE_LAT           RR_DECK.BOD         TRAXLE                        0     0
 500.00000000000      -452.81000000000     20.500000000000
0.00000000000000      -452.81000000000     20.500000000000
 500.00000000000      -451.81000000000     20.500000000000
0.00000000000000      -451.81000000000     20.500000000000
 500.00000000000      -452.81000000000     21.500000000000
0.00000000000000      -452.81000000000     21.500000000000
 500.00000000000

**** trailer front axle constraints

DISTANCE  DIST_RF_L            RR_DECK.BOD         TFAXLE                        0     0
 18.295000000000      -427.06000000000     34.221600000000
 18.295000000000      -401.81000000000     23.161200000000
 19.295000000000      -427.06000000000     34.221600000000
 19.295000000000      -401.81000000000     23.161200000000
```

```
 18.295000000000     -427.06000000000     35.000000000000
 18.295000000000     -401.81000000000     35.000000000000
 27.566200000000
DISTANCE  DIST_LF_L           RL_DECK.BOD          TFAXLE                      0     0
-18.295000000000     -427.06000000000     34.221600000000
-18.295000000000     -401.81000000000     23.161200000000
-17.295000000000     -427.06000000000     34.221600000000
-17.295000000000     -401.81000000000     23.161200000000
-18.295000000000     -427.06000000000     35.000000000000
-18.295000000000     -401.81000000000     35.000000000000
 27.566200000000

DISTANCE  DIST_RF_U           RR_DECK.BOD          TFAXLE                      0     0
0.0000000000000      -427.06000000000     29.221600000000
0.0000000000000      -401.81000000000     17.738800000000
 1.0000000000000     -427.06000000000     29.221600000000
 1.0000000000000     -401.81000000000     17.738800000000
0.0000000000000      -427.06000000000     30.000000000000
0.0000000000000      -401.81000000000     30.000000000000
 27.738400000000

**** trailer rear axle constraints

DISTANCE  DIST_RR_L           RR_DECK.BOD          TRAXLE                      0     0
 18.295000000000     -427.56000000000     34.221600000000
 18.295000000000     -452.56000000000     23.161200000000
 19.295000000000     -427.56000000000     34.221600000000
 19.295000000000     -452.56000000000     23.161200000000
 18.295000000000     -427.56000000000     35.000000000000
 18.295000000000     -452.56000000000     35.000000000000
 27.337381882000
DISTANCE  DIST_LR_L           RL_DECK.BOD          TRAXLE                      0     0
-18.295000000000     -427.56000000000     34.221600000000
-18.295000000000     -452.56000000000     23.161200000000
-17.295000000000     -427.56000000000     34.221600000000
-17.295000000000     -452.56000000000     23.161200000000
-18.295000000000     -427.56000000000     35.000000000000
-18.295000000000     -452.56000000000     35.000000000000
 27.337381882000

DISTANCE  DIST_RR_U           RR_DECK.BOD          TRAXLE                      0     0
0.0000000000000      -427.56000000000     29.221600000000
0.0000000000000      -452.56000000000     17.738800000000
 1.0000000000000     -427.56000000000     29.221600000000
 1.0000000000000     -452.56000000000     17.738800000000
0.0000000000000      -427.56000000000     30.000000000000
0.0000000000000      -452.56000000000     30.000000000000
 27.510992272900

**** trailer tires

TIRE      RFTIRE              RFWHL                RR_DECK.BOD          FULL
NONE                 NONE                 NONE                 NONE
 37.000000000000     -401.81000000000     20.502000000000
 21.200000000000     0.0000000000000      10.000000000000
 5000.0000000000      859436.69269624     0.0000000000000
0.8000000000000
TIRE      RRTIRE              RRWHL                RR_DECK.BOD          FULL
NONE                 NONE                 NONE                 NONE
 37.000000000000     -452.81000000000     20.502000000000
```

```
 21.200000000000     0.00000000000000     10.000000000000
 5000.0000000000      859436.69269624    0.00000000000000
0.80000000000000
TIRE       LFTIRE              LFWHL              RL_DECK.BOD         FULL
NONE                NONE                NONE                NONE
-37.000000000000    -401.81000000000     20.502000000000
 21.200000000000    0.00000000000000     10.000000000000
 5000.0000000000     859436.69269624    0.00000000000000
0.80000000000000
TIRE       LRTIRE              LRWHL              RL_DECK.BOD         FULL
NONE                NONE                NONE                NONE
-37.000000000000    -452.81000000000     20.502000000000
 21.200000000000    0.00000000000000     10.000000000000
 5000.0000000000     859436.69269624    0.00000000000000
0.80000000000000

**** trailer  leafsprings

TSDA       RF_SPRING           TFAXLE             R_SPRING                  0     0
BSTOP               NONE                NONE
 21.505000000000    -401.81000000000     20.500000000000
 21.505000000000    -401.81000000000     31.270000000000
 22.505000000000    -401.81000000000     20.500000000000
 22.505000000000    -401.81000000000     31.270000000000
 21.505000000000    -401.81000000000     22.270000000000
 21.505000000000    -401.81000000000     32.270000000000
 8772.0000000000     11.000000000000    20.0000000000000    0.00000000000000
TSDA       RR_SPRING           TRAXLE             R_SPRING                  0     0
BSTOP               NONE                NONE
 21.505000000000    -452.81000000000     20.500000000000
 21.505000000000    -452.81000000000     31.270000000000
 22.505000000000    -452.81000000000     20.500000000000
 22.505000000000    -452.81000000000     31.270000000000
 21.505000000000    -452.81000000000     22.270000000000
 21.505000000000    -452.81000000000     32.270000000000
 8772.0000000000     11.000000000000    20.0000000000000    0.00000000000000
TSDA       LF_SPRING           TFAXLE             L_SPRING                  0     0
BSTOP               NONE                NONE
-21.505000000000    -401.81000000000     20.500000000000
-21.505000000000    -401.81000000000     31.270000000000
-22.505000000000    -401.81000000000     20.500000000000
-22.505000000000    -401.81000000000     31.270000000000
-21.505000000000    -401.81000000000     22.270000000000
-21.505000000000    -401.81000000000     32.270000000000
 8772.0000000000     11.000000000000    20.0000000000000    0.00000000000000
TSDA       LR_SPRING           TRAXLE             L_SPRING                  0     0
BSTOP               NONE                NONE
-21.505000000000    -452.81000000000     20.500000000000
-21.505000000000    -452.81000000000     31.270000000000
-22.505000000000    -452.81000000000     20.500000000000
-22.505000000000    -452.81000000000     31.270000000000
-21.505000000000    -452.81000000000     22.270000000000
-21.505000000000    -452.81000000000     32.270000000000
 8772.0000000000     11.000000000000    20.0000000000000    0.00000000000000

**** springs between the L_SPRING & R_SPRING and M871

TSDA       RF_SPRINGDAMP       RR_DECK.BOD        R_SPRING                  0     0
BSTOP               NONE                NONE
 21.505000000000    -401.81000000000     20.500000000000
```

```
 21.505000000000     -401.81000000000     31.270000000000
 22.505000000000     -401.81000000000     20.500000000000
 22.505000000000     -401.81000000000     31.270000000000
 21.505000000000     -401.81000000000     22.270000000000
 21.505000000000     -401.81000000000     32.270000000000
 20.000000000000      11.000000000000     10.000000000000    0.00000000000000
TSDA       RR_SPRINGDAMP        RR_DECK.BOD          R_SPRING                  0     0
BSTOP                NONE                 NONE
 21.505000000000     -452.81000000000     20.500000000000
 21.505000000000     -452.81000000000     31.270000000000
 22.505000000000     -452.81000000000     20.500000000000
 22.505000000000     -452.81000000000     31.270000000000
 21.505000000000     -452.81000000000     22.270000000000
 21.505000000000     -452.81000000000     32.270000000000
 20.000000000000      11.000000000000     10.000000000000    0.00000000000000
TSDA       LF_SPRINGDAMP        RL_DECK.BOD          L_SPRING                  0     0
BSTOP                NONE                 NONE
-21.505000000000     -401.81000000000     20.500000000000
-21.505000000000     -401.81000000000     31.270000000000
-22.505000000000     -401.81000000000     20.500000000000
-22.505000000000     -401.81000000000     31.270000000000
-21.505000000000     -401.81000000000     22.270000000000
-21.505000000000     -401.81000000000     32.270000000000
 20.000000000000      11.000000000000     10.000000000000    0.00000000000000
TSDA       LR_SPRINGDAMP        RL_DECK.BOD          L_SPRING                  0     0
BSTOP                NONE                 NONE
-21.505000000000     -452.81000000000     20.500000000000
-21.505000000000     -452.81000000000     31.270000000000
-22.505000000000     -452.81000000000     20.500000000000
-22.505000000000     -452.81000000000     31.270000000000
-21.505000000000     -452.81000000000     22.270000000000
-21.505000000000     -452.81000000000     32.270000000000
 20.000000000000      11.000000000000     10.000000000000    0.00000000000000

**** payload bracketed to frame to allow for ease of movement of payload

BRACKET    PAYLOAD_1.BRACK      PAYLOAD1.BOD         F_DECK.BOD                0     0
0.00000000000000     -191.56000000000     65.500000000000
0.00000000000000     -191.56000000000     65.500000000000
0.00000000000000     -191.56000000000     66.500000000000
0.00000000000000     -191.56000000000     66.500000000000
 1.000000000000      -191.56000000000     65.500000000000
 1.000000000000      -191.56000000000     65.500000000000
BRACKET    PAYLOAD_2.BRACK      PAYLOAD2.BOD         RR_DECK.BOD               0     0
24.000000000000      -343.70000000000     55.000000000000
24.000000000000      -343.70000000000     55.000000000000
24.000000000000      -343.70000000000     56.000000000000
24.000000000000      -343.70000000000     56.000000000000
 25.000000000000     -343.70000000000     55.000000000000
 25.000000000000     -343.70000000000     55.000000000000
BRACKET    PAYLOAD_3.BRACK      PAYLOAD3.BOD         RL_DECK.BOD               0     0
-24.000000000000     -343.70000000000     55.000000000000
-24.000000000000     -343.70000000000     55.000000000000
-24.000000000000     -343.70000000000     56.000000000000
-24.000000000000     -343.70000000000     56.000000000000
 -23.00000000000     -343.70000000000     55.000000000000
 -23.00000000000     -343.70000000000     55.000000000000

***   Bracket Joints used to generate reaction forces at gussets for
***   FEA.
```

```
BRACKET    L_GUS.BRACK          RL_DECK.BOD          F_DECK.BOD              0     0
-48.000000000000    -252.31000000000     55.000000000000
-48.000000000000    -252.31000000000     55.000000000000
-48.000000000000    -252.31000000000     56.000000000000
-48.000000000000    -252.31000000000     56.000000000000
 -47.00000000000    -252.31000000000     55.000000000000
 -47.00000000000    -252.31000000000     55.000000000000
BRACKET    R_GUS.BRACK          RR_DECK.BOD          F_DECK.BOD              0     0
 48.000000000000    -252.31000000000     55.000000000000
 48.000000000000    -252.31000000000     55.000000000000
 48.000000000000    -252.31000000000     56.000000000000
 48.000000000000    -252.31000000000     56.000000000000
  49.00000000000    -252.31000000000     55.000000000000
  49.00000000000    -252.31000000000     55.000000000000

**** joints which attach center body (leaf spring) to trailer chassis

REVOLUTE  RTRUNNION            RR_DECK.BOD          R_SPRING                0     0
 21.505000000000    -426.81000000000     33.049100000000
 21.505000000000    -426.81000000000     33.049100000000
 22.505000000000    -426.81000000000     33.049100000000
 22.505000000000    -426.81000000000     33.049100000000
 21.505000000000    -426.81000000000     34.049100000000
 21.505000000000    -426.81000000000     34.049100000000
REVOLUTE  LTRUNNION            RL_DECK.BOD          L_SPRING                0     0
-21.505000000000    -426.81000000000     33.049100000000
-21.505000000000    -426.81000000000     33.049100000000
-22.505000000000    -426.81000000000     33.049100000000
-22.505000000000    -426.81000000000     33.049100000000
-21.505000000000    -426.81000000000     34.049100000000
-21.505000000000    -426.81000000000     34.049100000000

**** trailer wheel hubs revolute joints

REVOLUTE  RF_REV               RFWHL                TFAXLE                  0     0
 37.000000000000    -401.81000000000     20.500000000000
 37.000000000000    -401.81000000000     20.500000000000
 38.000000000000    -401.81000000000     20.500000000000
 38.000000000000    -401.81000000000     20.500000000000
 37.000000000000    -401.81000000000     21.500000000000
 37.000000000000    -401.81000000000     21.500000000000
REVOLUTE  RR_REV               RRWHL                TRAXLE                  0     0
 37.000000000000    -452.81000000000     20.500000000000
 37.000000000000    -452.81000000000     20.500000000000
 38.000000000000    -452.81000000000     20.500000000000
 38.000000000000    -452.81000000000     20.500000000000
 37.000000000000    -452.81000000000     21.500000000000
 37.000000000000    -452.81000000000     21.500000000000
REVOLUTE  LF_REV               LFWHL                TFAXLE                  0     0
-37.000000000000    -401.81000000000     20.500000000000
-37.000000000000    -401.81000000000     20.500000000000
-38.000000000000    -401.81000000000     20.500000000000
-38.000000000000    -401.81000000000     20.500000000000
-37.000000000000    -401.81000000000     21.500000000000
-37.000000000000    -401.81000000000     21.500000000000
REVOLUTE  LR_REV               LRWHL                TRAXLE                  0     0
-37.000000000000    -452.81000000000     20.500000000000
-37.000000000000    -452.81000000000     20.500000000000
-38.000000000000    -452.81000000000     20.500000000000
```

-38.000000000000	-452.81000000000	20.500000000000	
-37.000000000000	-452.81000000000	21.500000000000	
-37.000000000000	-452.81000000000	21.500000000000	

**** trailer chassis

BODY	F_DECK.BOD	POSITIVE	PARAMETERSFALSEFALSEFALSE	
NONE		NONE	NONE	
NONE		NONE	NONE	
0.0000000000000		-191.56000000000	62.750000000000	
0.0000000000000		0.0000000000000	0.0000000000000	
6.9551920000000		7484.0000000000	5359.0000000000	12808.000000000
0.0000000000000		0.0000000000000	0.0000000000000	
0.0000000000000		0.0000000000000	0.0000000000000	
0.0000000000000		0.0000000000000	0.0000000000000	
BODY	RL_DECK.BOD	POSITIVE	PARAMETERSFALSEFALSEFALSE	
NONE		NONE	NONE	
NONE		NONE	NONE	
-24.000000000000		-343.70000000000	50.000000000000	
0.0000000000000		0.0000000000000	0.0000000000000	
13.910384000000		69413.105000000	2786.0000000000	71968.000000000
0.0000000000000		0.0000000000000	0.0000000000000	
0.0000000000000		0.0000000000000	0.0000000000000	
0.0000000000000		0.0000000000000	0.0000000000000	
BODY	RR_DECK.BOD	POSITIVE	PARAMETERSFALSEFALSEFALSE	
NONE		NONE	NONE	
NONE		NONE	NONE	
24.000000000000		-343.70000000000	50.000000000000	
0.0000000000000		0.0000000000000	0.0000000000000	
13.910384000000		69413.105000000	2786.0000000000	71968.000000000
0.0000000000000		0.0000000000000	0.0000000000000	
0.0000000000000		0.0000000000000	0.0000000000000	
0.0000000000000		0.0000000000000	0.0000000000000	

**** trailer axles

BODY	TFAXLE	POSITIVE	PARAMETERSFALSEFALSEFALSE	
NONE		NONE	NONE	
NONE		NONE	NONE	
0.0000000000000		-401.81000000000	20.500000000000	
0.0000000000000		0.0000000000000	0.0000000000000	
1.9067000000000		64.920000000000	1564.0000000000	1564.0000000000
0.0000000000000		0.0000000000000	0.0000000000000	
0.0000000000000		0.0000000000000	0.0000000000000	
0.0000000000000		0.0000000000000	0.0000000000000	
BODY	TRAXLE	POSITIVE	PARAMETERSFALSEFALSEFALSE	
NONE		NONE	NONE	
NONE		NONE	NONE	
0.0000000000000		-452.81000000000	20.500000000000	
0.0000000000000		0.0000000000000	0.0000000000000	
1.9067000000000		64.920000000000	1564.0000000000	1564.0000000000
0.0000000000000		0.0000000000000	0.0000000000000	
0.0000000000000		0.0000000000000	0.0000000000000	
0.0000000000000		0.0000000000000	0.0000000000000	

**** trailer wheel hubs

BODY	RFWHL	POSITIVE	PARAMETERSFALSEFALSEFALSE
NONE		NONE	NONE
NONE		NONE	NONE

```
 37.000000000000    -401.81000000000    20.500000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.3900000000000     44.000000000000    24.500000000000    24.500000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.0000000000000    0.0000000000000    0.0000000000000
BODY      RRWHL               POSITIVE PARAMETERSFALSEFALSEFALSE
NONE                NONE               NONE
NONE                NONE               NONE
 37.000000000000    -452.81000000000    20.500000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.3900000000000     44.000000000000    24.500000000000    24.500000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.0000000000000    0.0000000000000    0.0000000000000
BODY      LFWHL               POSITIVE PARAMETERSFALSEFALSEFALSE
NONE                NONE               NONE
NONE                NONE               NONE
-37.000000000000    -401.81000000000    20.500000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.3900000000000     44.000000000000    24.500000000000    24.500000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.0000000000000    0.0000000000000    0.0000000000000
BODY      LRWHL               POSITIVE PARAMETERSFALSEFALSEFALSE
NONE                NONE               NONE
NONE                NONE               NONE
-37.000000000000    -452.81000000000    20.500000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.3900000000000     44.000000000000    24.500000000000    24.500000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.0000000000000    0.0000000000000    0.0000000000000

**** center body to simulate leafspring coupling between axles

BODY      R_SPRING            POSITIVE PARAMETERSFALSEFALSEFALSE
NONE                NONE               NONE
NONE                NONE               NONE
 21.505000000000    -426.81000000000    28.925200000000
0.0000000000000    0.0000000000000    0.0000000000000
0.5200000000000     25.000000000000    1.0000000000000    25.000000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.0000000000000    0.0000000000000    0.0000000000000
BODY      L_SPRING            POSITIVE PARAMETERSFALSEFALSEFALSE
NONE                NONE               NONE
NONE                NONE               NONE
-21.505000000000    -426.81000000000    28.925200000000
0.0000000000000    0.0000000000000    0.0000000000000
0.5200000000000     25.000000000000    1.0000000000000    25.000000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.0000000000000    0.0000000000000    0.0000000000000
0.0000000000000    0.0000000000000    0.0000000000000

**** trailer payload: Front and Rear differ. ***
BODY      PAYLOAD1.BOD        POSITIVE PARAMETERSFALSEFALSEFALSE
NONE                NONE               NONE
NONE                NONE               NONE
0.0000000000000    -191.56000000000    84.000000000000
```

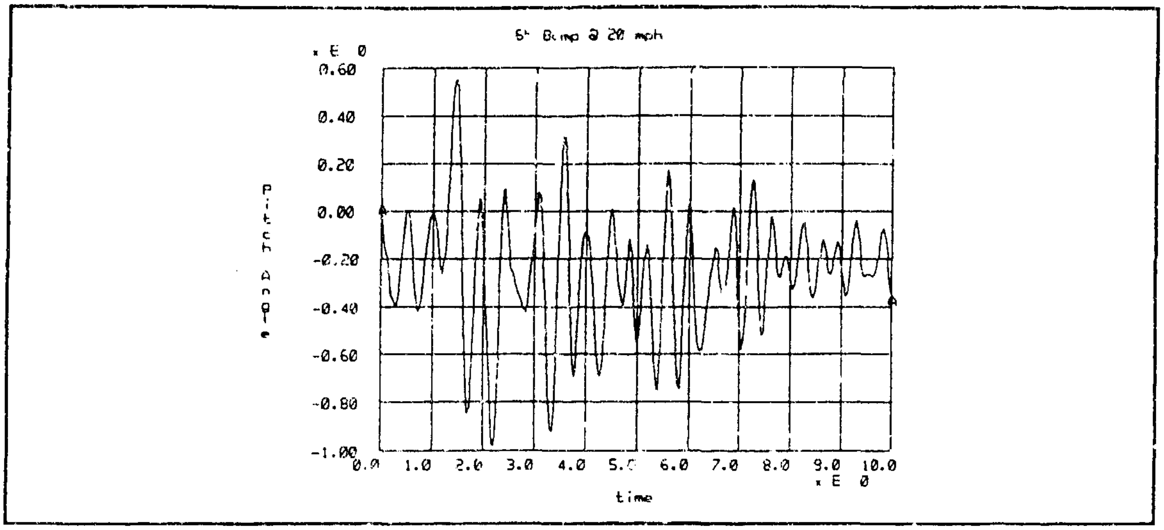
```
0.00000000000000    0.00000000000000    0.00000000000000
7.77121541809000    59007.8100000000    44762.2000000000    85865.130000000
0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
BODY      PAYLOAD2.BOD           POSITIVE   PARAMETERSFALSEFALSEFALSE
NONE                NONE                NONE
NONE                NONE                NONE
-24.000000000000    -343.70000000000    96.000000000000
0.00000000000000    0.00000000000000    0.00000000000000
28.4944565330000    165581.000000000    43767.0000000000    165581.00000000
0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
BODY      PAYLOAD3.BOD           POSITIVE   PARAMETERSFALSEFALSEFALSE
NONE                NONE                NONE
NONE                NONE                NONE
24.0000000000000    -343.70000000000    96.000000000000
0.00000000000000    0.00000000000000    0.00000000000000
28.4944565330000    165581.000000000    43767.0000000000    165581.00000000
0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000

**** trailer initial conditions

INITIAL   F_DECKO.INIT          TFAXLE                NONE
NONE                ORIENTATION              0
0.00000000000000    0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
INITIAL   TFAXLE-Z.IC           TFAXLE                NONE
NONE                Z                        0
0.00000000000000    0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
INITIAL   TFAXLE-E2.IC          TFAXLE                NONE
NONE                E2                       0
0.00000000000000    0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
INITIAL   TRAXLE-Z.IC           TRAXLE                NONE
NONE                Z                        0
0.00000000000000    0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
INITIAL   TRAXLE-E2.IC          TRAXLE                NONE
NONE                E2                       0
0.00000000000000    0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
INITIAL   LFWHL-E1.IC           LFWHL                 NONE
NONE                E1                       0
0.00000000000000    0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
INITIAL   RFWHL-E1.IC           RFWHL                 NONE
NONE                E1                       0
0.00000000000000    0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
```

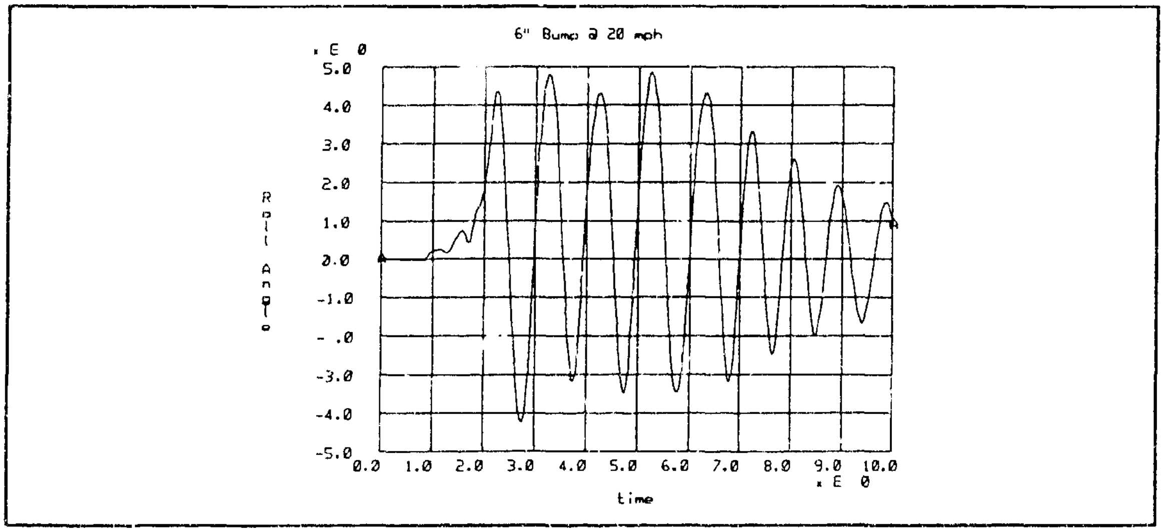
```
0.00000000000000    0.00000000000000    0.00000000000000
INITIAL   LRWHL-E1.IC        LRWHL              NONE
NONE                E1                  0
0.00000000000000    0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
INITIAL   RRWHL-E1.IC        RRWHL              NONE
NONE                E1                  0
0.00000000000000    0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000
ROAD      ROAD               NONE                    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000    0.00000000000000
0.00000000000000    0.00000000000000    0.00000000000000    0.00000000000000
201.000000000000    20.0000000000000    0.50000000000000    3.00000000000000

**** tractor tire lateral stiffness curve
CURVE     TIRELS.CUR         PAIRED.XY                 13    1
0.12500000000000    0.50000000000000E-020.10000000000000E-01 1.00000000000000
0.00000000000000    0.00000000000000    CUBIC
0.00000000000000    0.00000000000000     4.00000000000000   0.50000000000000
 10.000000000000    0.70000000000000    15.000000000000     0.80000000000000
 20.000000000000    0.90000000000000    30.000000000000     0.85000000000000
 40.000000000000    0.82000000000000    50.000000000000     0.80000000000000
 60.000000000000    0.78000000000000    70.000000000000     0.75000000000000
 80.000000000000    0.73000000000000    90.000000000000     0.70000000000000
 100.00000000000    0.65000000000000

**** bump steer curves
CURVE     TSBSL.CUR          PAIRED.XY                 13    3
0.00000000000000     50000.000000000    0.17500000000000E-01 1.00000000000000
0.00000000000000    0.00000000000000    LINEAR
 38.000000000000    0.00000000000000     38.400000000000    0.00000000000000
 38.600000000000    0.00000000000000     38.700000000000    0.00000000000000
 38.800000000000     600.00000000000     38.900000000000     1800.0000000000
 39.000000000000     3700.0000000000     39.100000000000     6500.0000000000
 39.200000000000     10150.000000000     39.300000000000     15000.000000000
 39.400000000000     20000.000000000     39.600000000000     30000.000000000
 40.000000000000     50000.000000000
CURVE     TSBSR.CUR          PAIRED.XY                 13    4
 50000.000000000    0.00000000000000    0.17500000000000E-01 1.00000000000000
0.00000000000000    0.00000000000000    LINEAR
-31.000000000000    -50000.000000000    -30.600000000000    -30000.000000000
-30.400000000000    -20000.000000000    -30.300000000000    -15000.000000000
-30.200000000000    -10150.000000000    -30.100000000000    -6500.0000000000
-30.000000000000    -3700.0000000000    -29.900000000000    -1800.0000000000
-29.800000000000    -600.00000000000    -29.700000000000    0.00000000000000
-29.600000000000    0.00000000000000    -29.400000000000    0.00000000000000
-29.000000000000    0.00000000000000
CURVE     TBSTOP.CUR         PAIRED.XY                  2    6
50000.0000000000     50000.000000000     1.0000000000000     1.000000000000000
0.00000000000000    0.00000000000000    LINEAR
-3.0000000000000    0.00000000000000     3.0000000000000    0.00000000000000

**** trailer bump stop curve
CURVE     BSTOP              PAIRED.XY                  4   10
17544.0000000000     17544.000000000     1.0000000000000     1.000000000000000
0.00000000000000    0.00000000000000    LINEAR
 0.0000000000000    -9500.0000000000     0.5000000000000     9400.00000000000
 1.0000000000000     17800.000000000     1.5000000000000     25600.0000000000
```

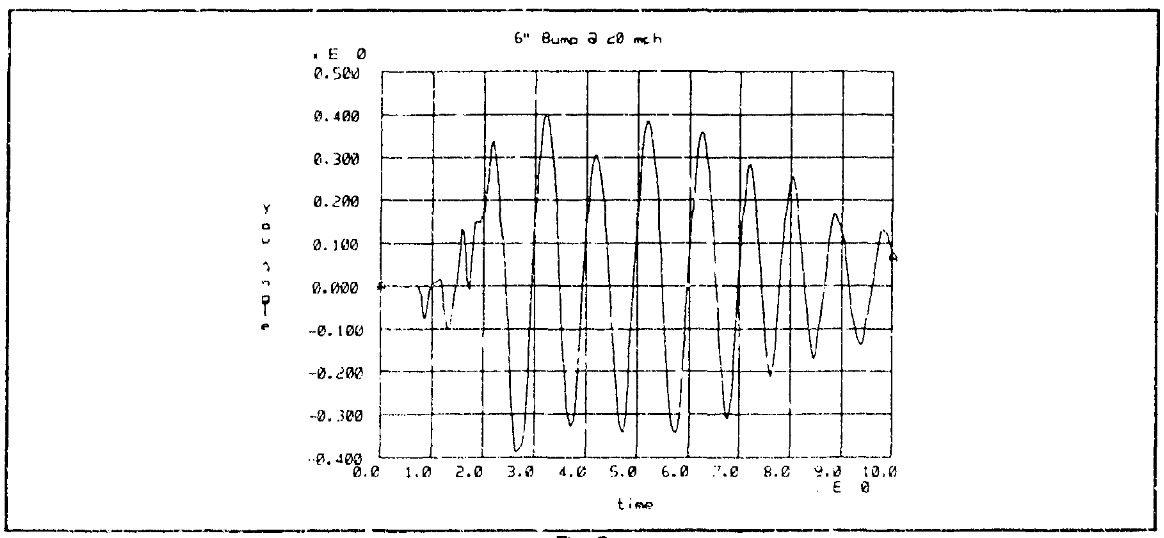
```
CURVE       BSTOP2                    PAIRED.XY                  3    10
0.00000000000000    5000.0000000000    1.0000000000000    1.0000000000000
0.00000000000000    0.00000000000000   LINEAR
-10.000000000000    0.00000000000000   5.0000000000000    0.00000000000000
 15.000000000000    75000.000000000

**** hitch roll curves ****
CURVE       BLOCKS_OUT                PAIRED.XY                  7    10
0.00000000000000    5000.0000000000    1.0000000000000    1.0000000000000
0.00000000000000    0.00000000000000   LINEAR
-0.1745000000000    -100000.00000000   -0.122200000000    0.00000000000000
-0.0698000000000    0.0000000000000     0.000000000000    0.00000000000000
 0.0698000000000    0.0000000000000     0.122200000000    0.00000000000000
 0.1745000000000    100000.00000000
CURVE       BLOCKS_IN                 PAIRED.XY                  2    10
 100000000.00000    100000000.00000    1.0000000000000    1.0000000000000
0.00000000000000    0.00000000000000   LINEAR
-10.000000000000    -100000000.00000   10.000000000000    100000000.000000
USERFORCE 352.
```

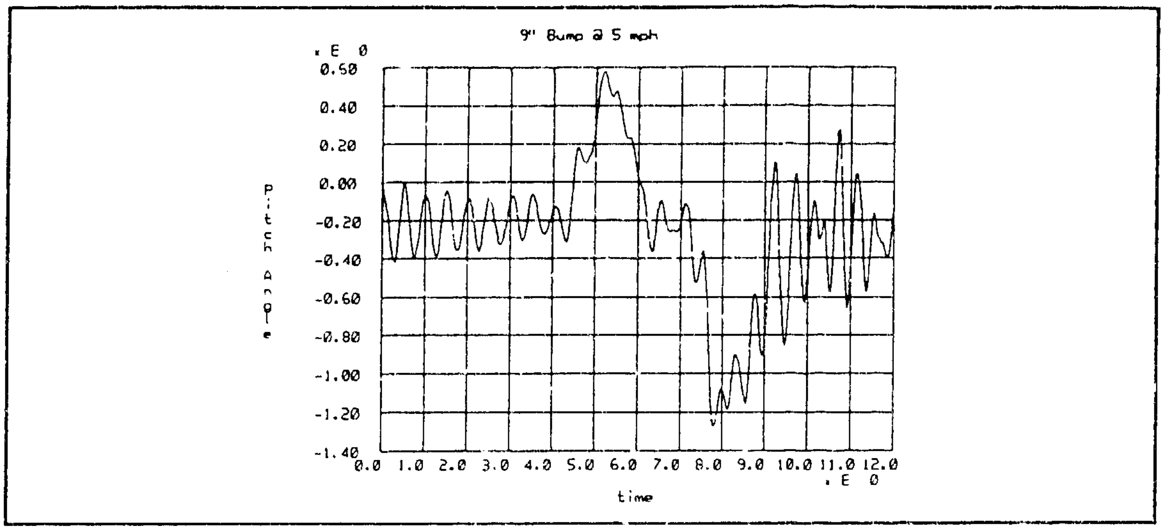
APPENDIX B

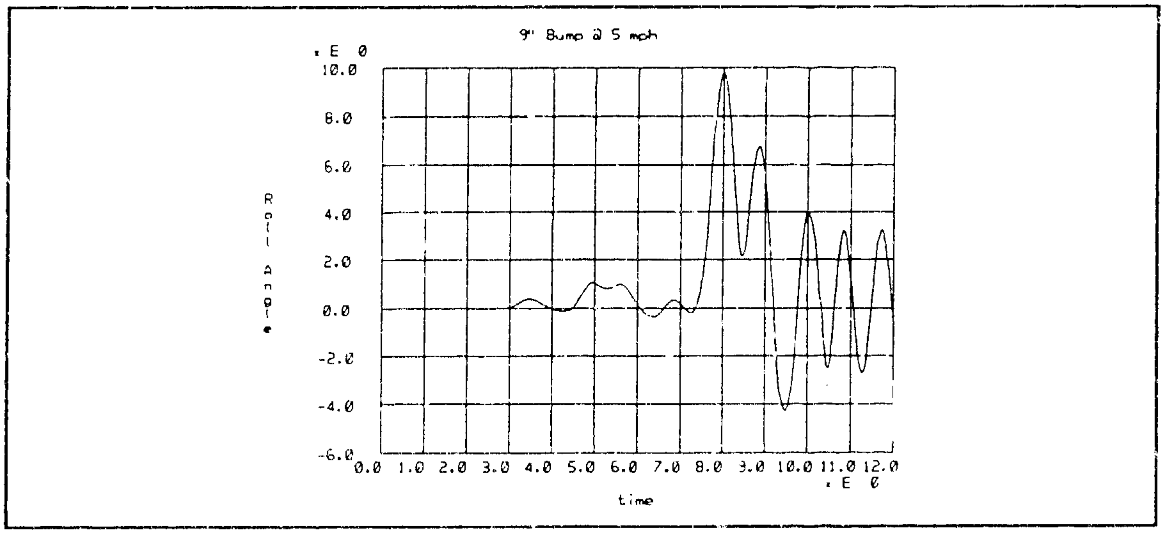
DADS Simulation Time Histories

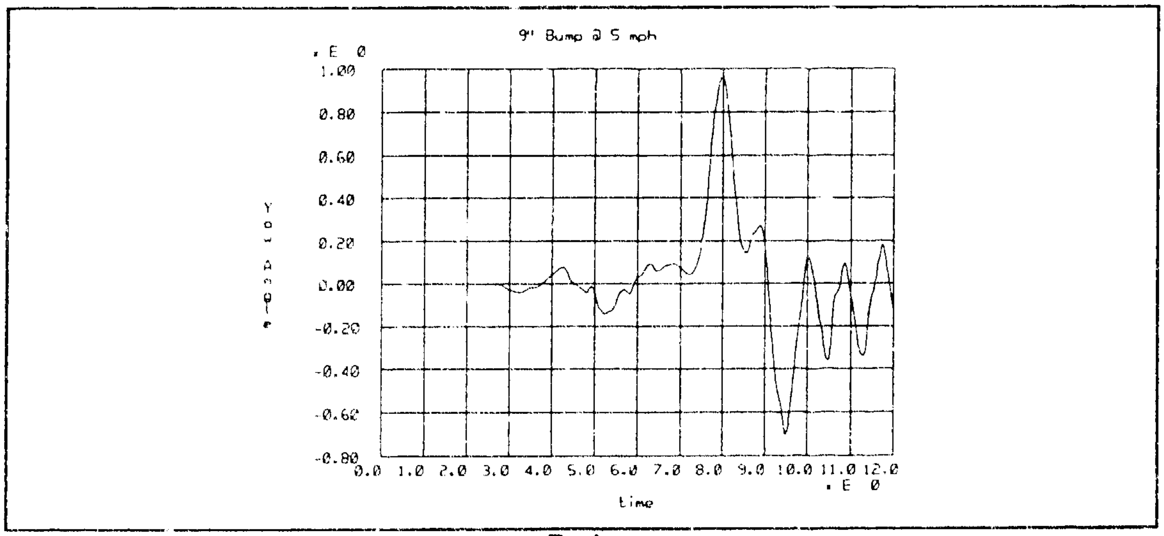

6" Bump @ 20 mph
x E 0
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Pitch Angle
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
x E 0
time

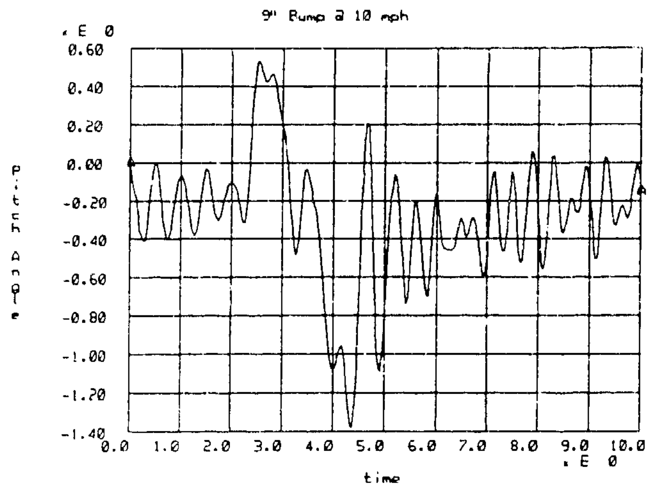

6" Bump @ 20 mph
x E 0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-3.0
-4.0
-5.0
Roll Angle
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
x E 0
time

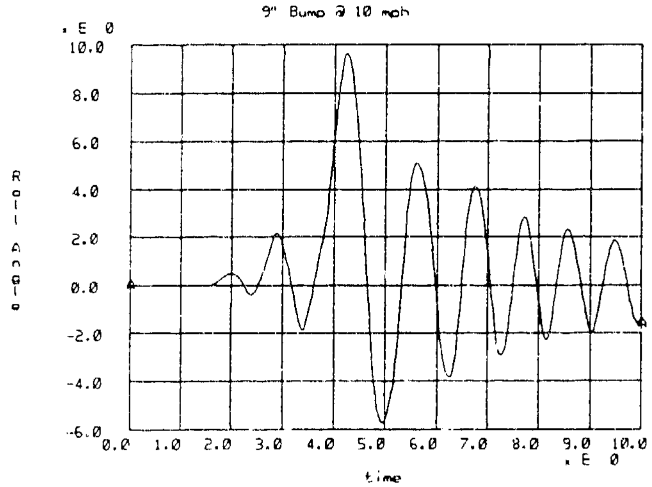

6" Bump @
x E 0
0.500
0.400
0.300
0.200
0.100
0.000
-0.100
-0.200
-0.300
-0.400
0.0 1.0 2.0 3.0 4.0 5.0 6.0 8.0 10.0
E 0
time

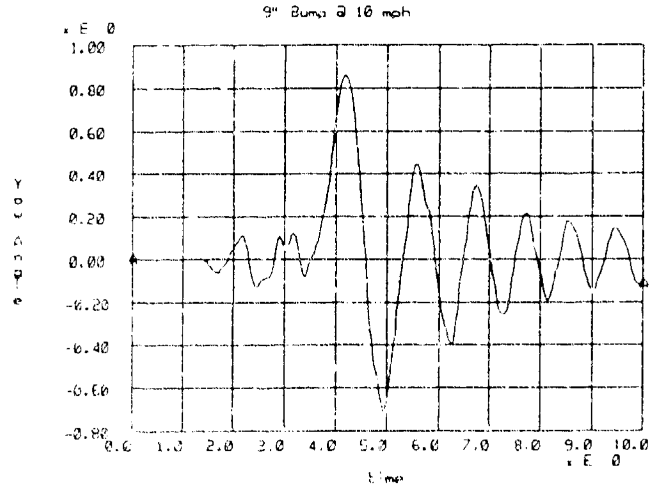

9" Bump @ 5 mph
E 0
Pitch Angle
time

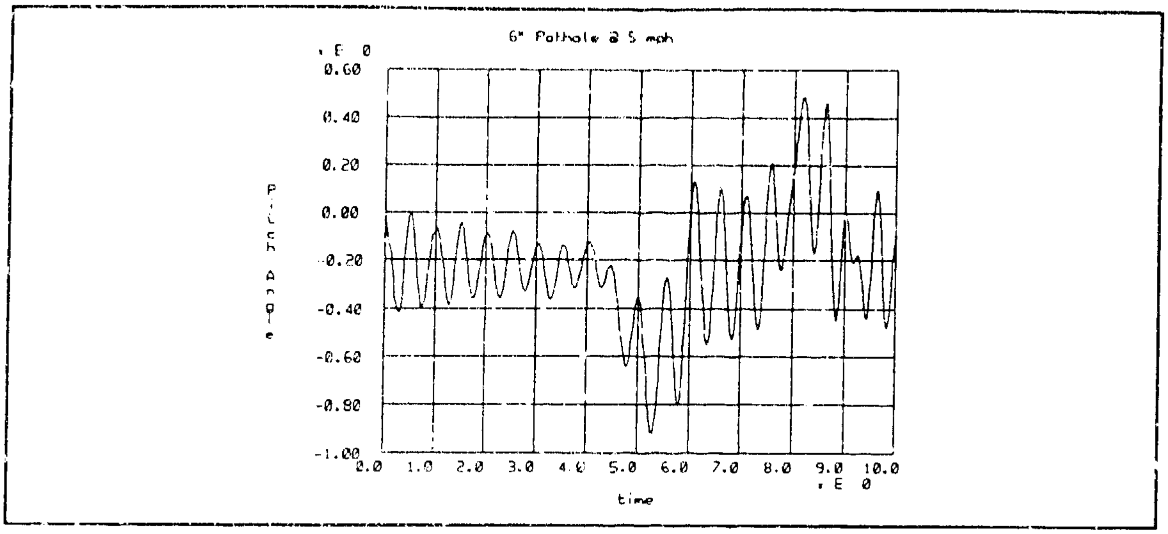

9" Bump @ 5 mph
E 0
Roll Angle
time

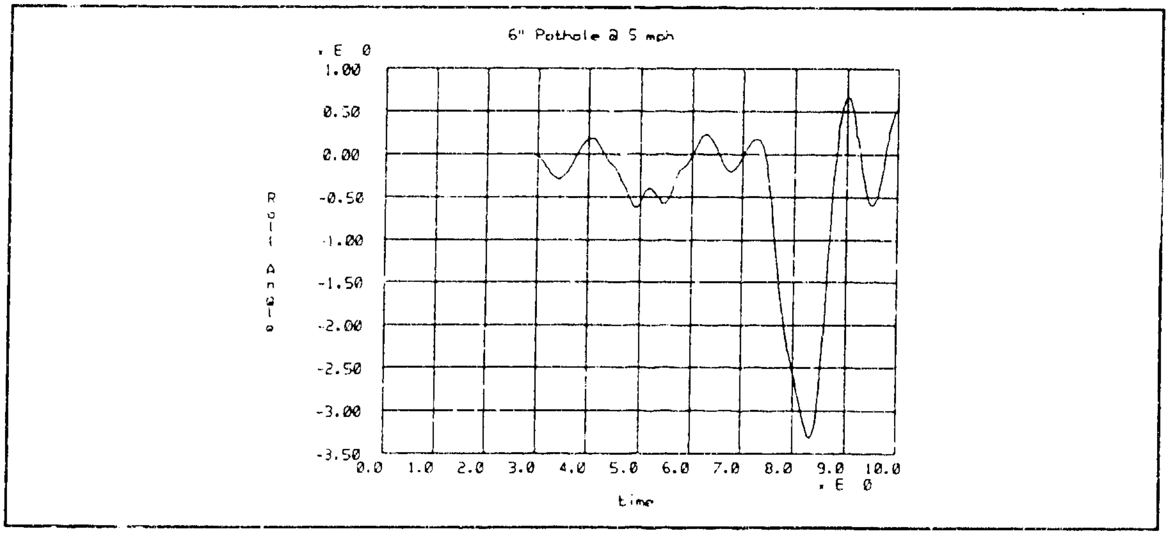

9" Bump @ 5 mph
E 0
Yaw Angle
time

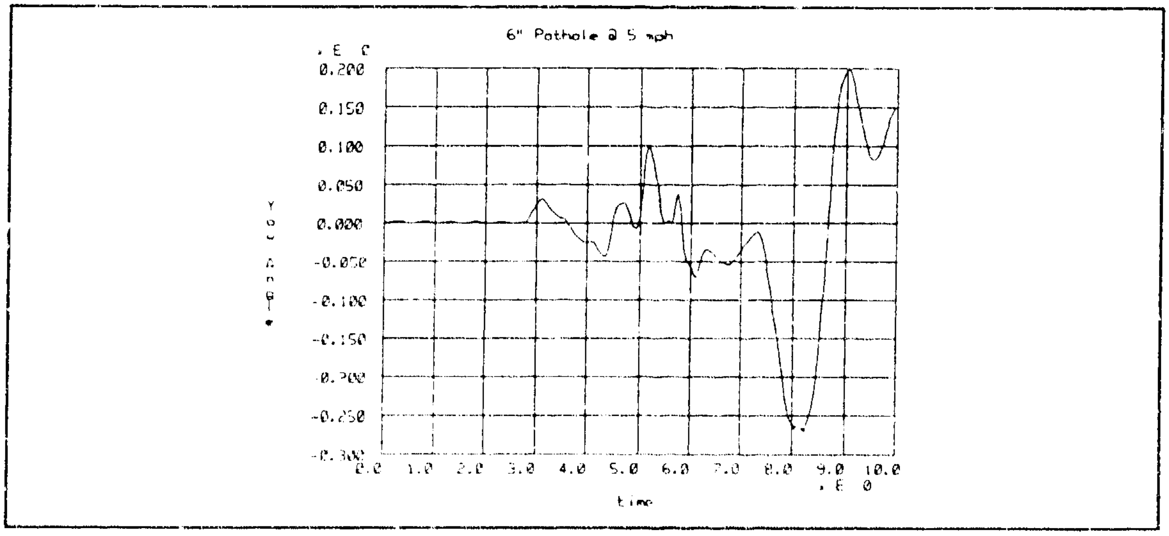

9" Bump @ 10 mph
x E 0
Pitch Angle
time
x E 0

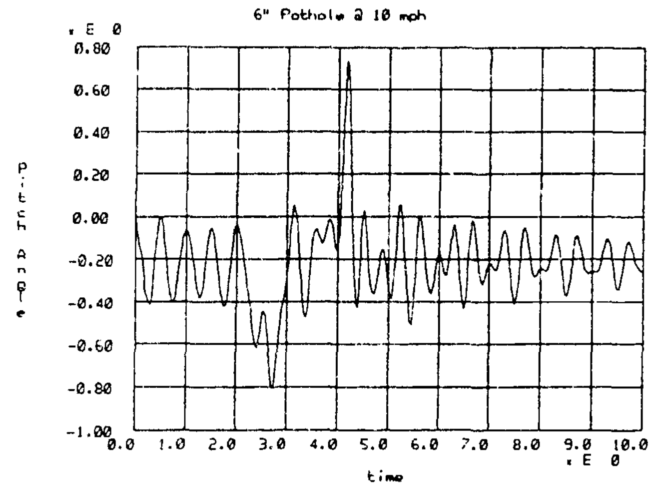

9" Bump @ 10 mph
x E 0
Roll Angle
time
x E 0

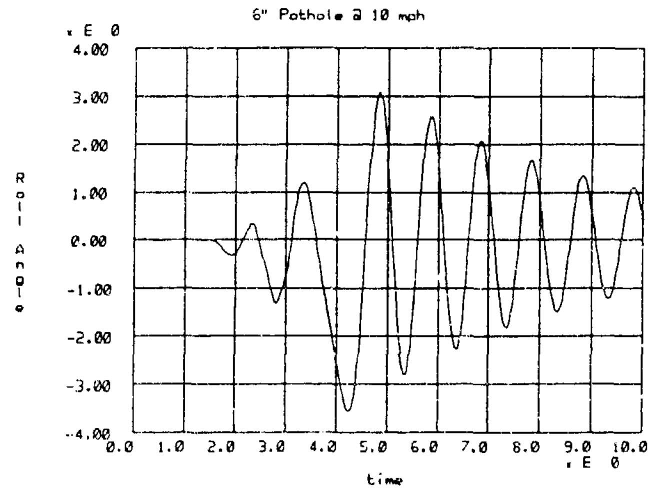

9" Bump @ 10 mph
x E 0
Yaw Angle
time
x E 0

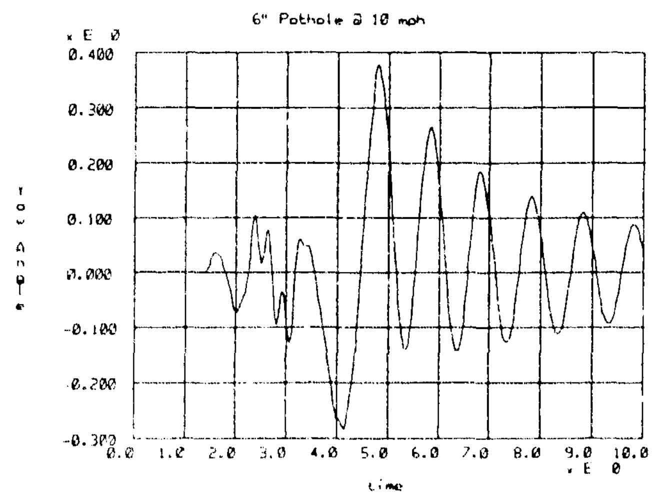

6" Pothole @ 5 mph
Pitch Angle
time
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0

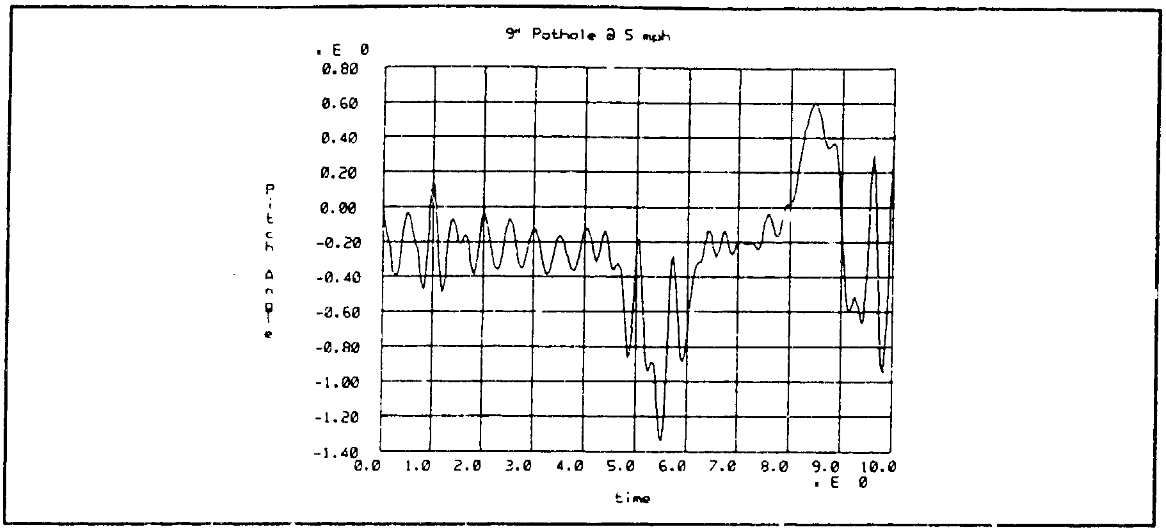

6" Pothole @ 5 mph
Roll Angle
time
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
-3.50
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0


6" Pothole @ 5 mph
Yaw Angle
time
0.200
0.150
0.100
0.050
0.000
-0.050
-0.100
-0.150
-0.200
-0.250
-0.300
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0

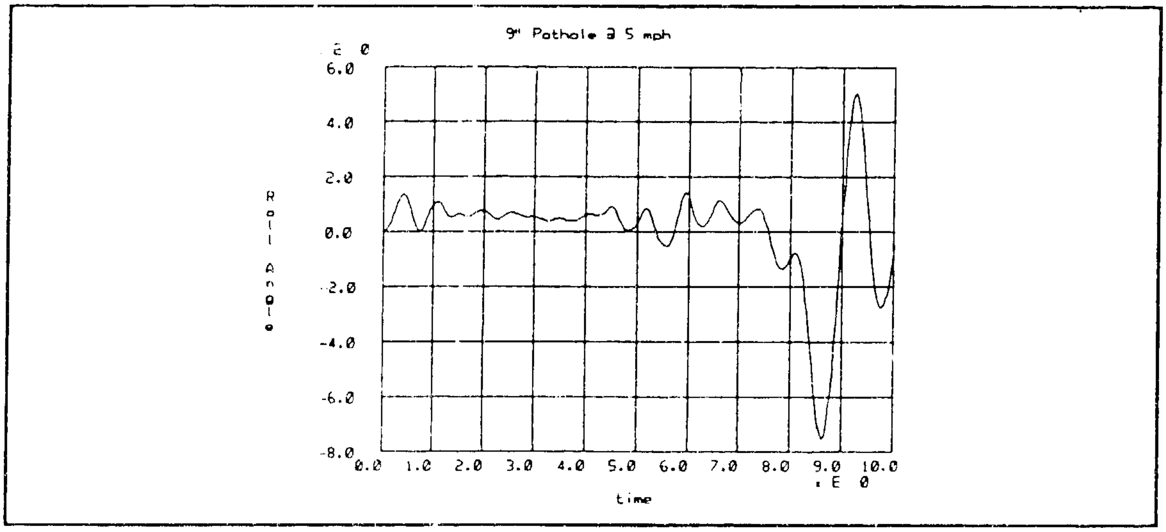

6" Pothole @ 10 mph
x E 0
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Pitch Angle
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
x E 0
time


6" Pothole @ 10 mph
x E 0
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
Roll Angle
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
x E 0
time

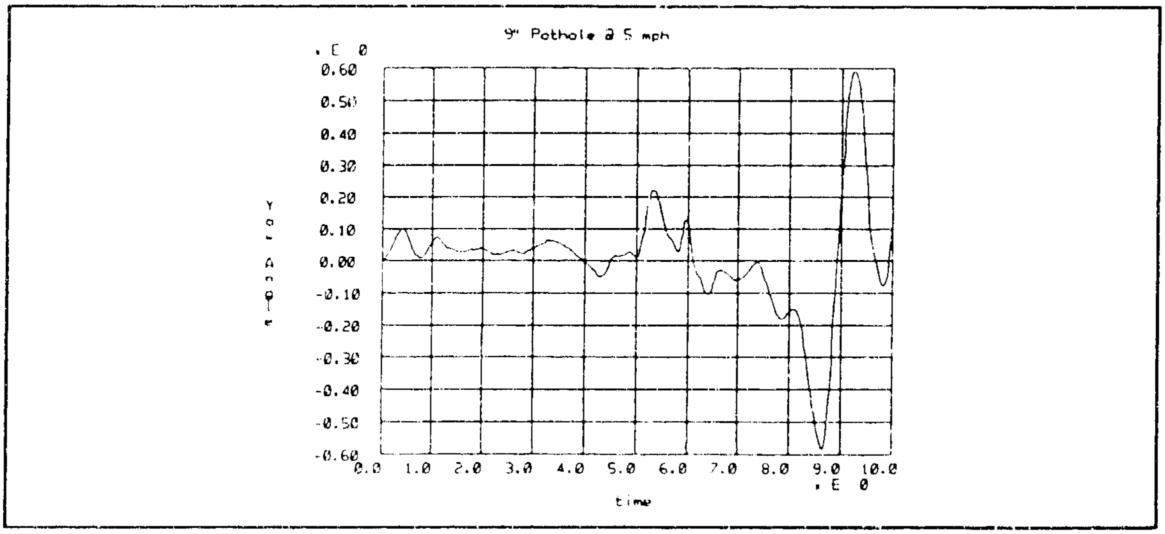

6" Pothole @ 10 mph
x E 0
0.400
0.300
0.200
0.100
0.000
-0.100
-0.200
-0.300
Yaw Angle
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
x E 0
time



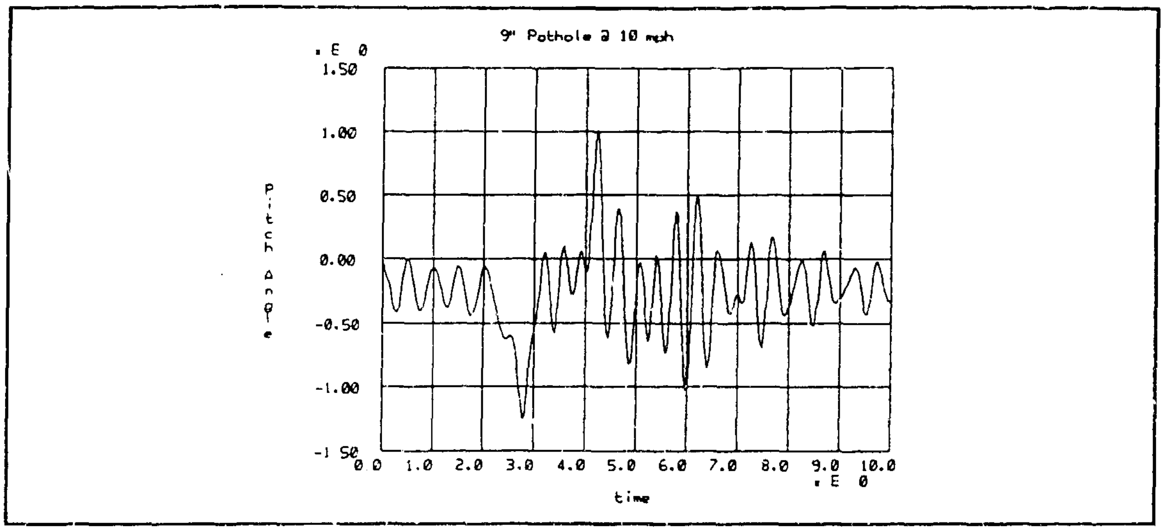
9" Pothole @ 5 mph
E 0
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
Pitch Angle
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
E 0
time

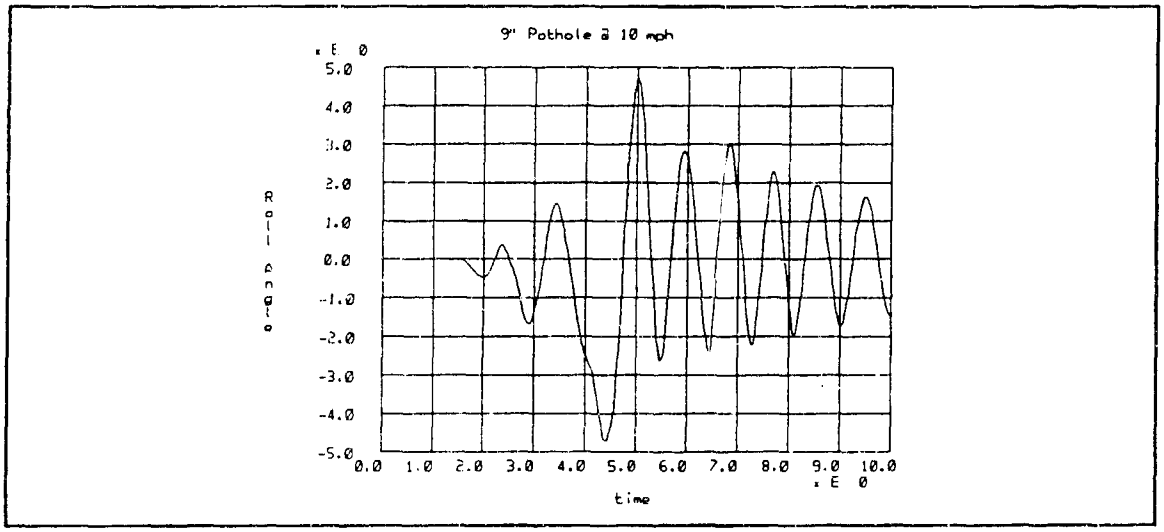


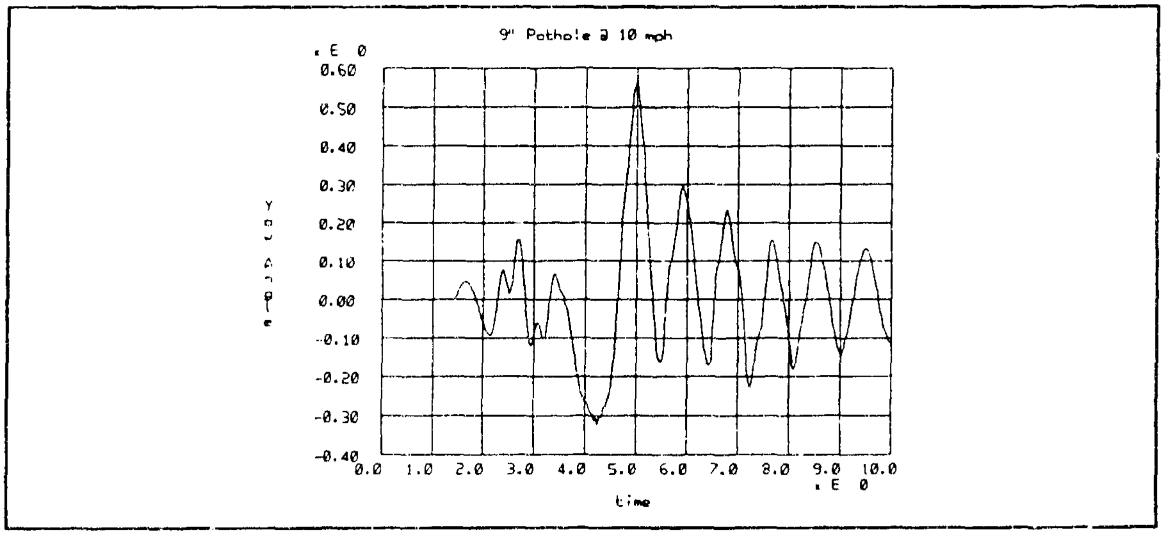
9" Pothole @ 5 mph
E 0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
Roll Angle
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
E 0
time

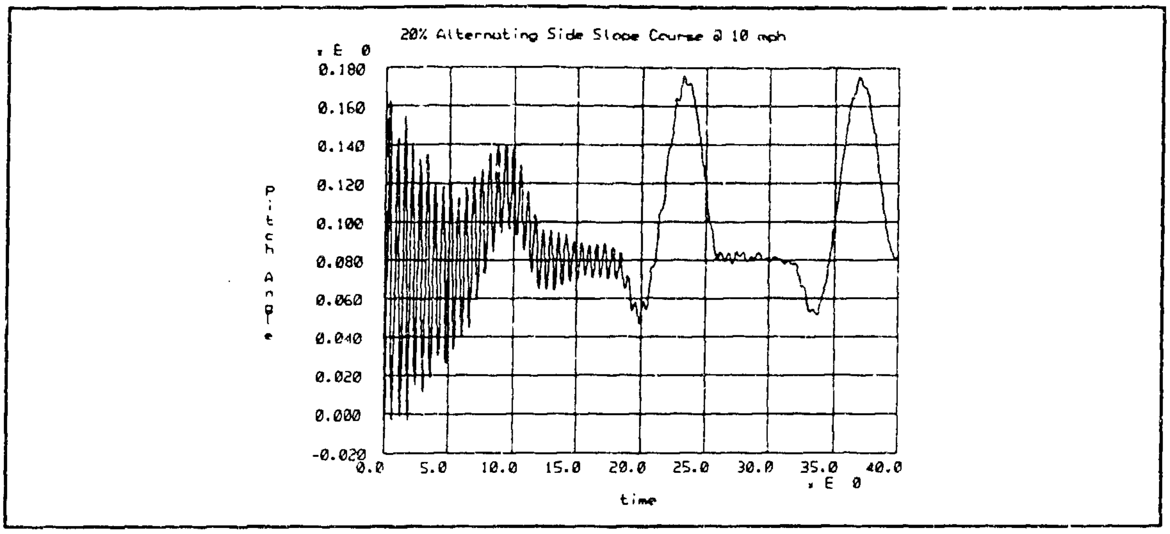


9" Pothole @ 5 mph
E 0
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
Yaw Angle
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
E 0
time

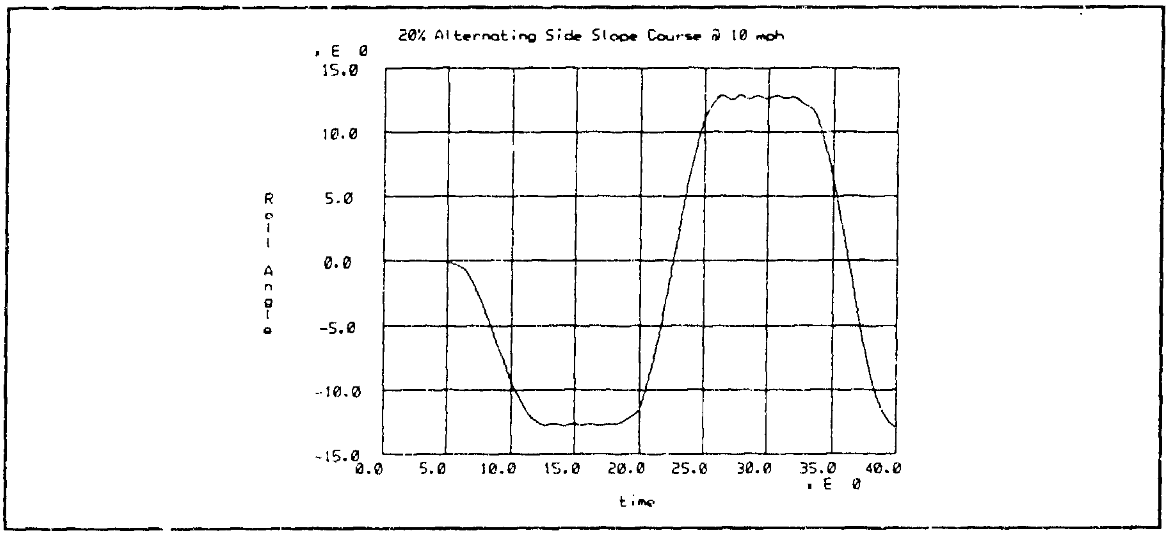

9" Pothole @ 10 mph
x E 0
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
Pitch Angle
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
x E 0
time


9" Pothole @ 10 mph
x E 0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
Roll Angle
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
x E 0
time

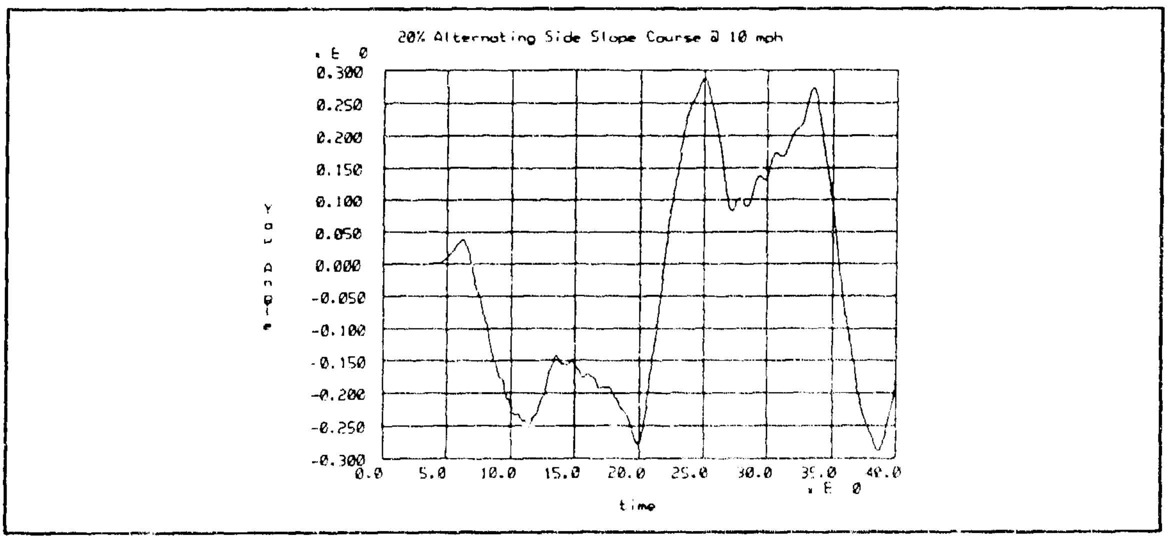

9" Pothole @ 10 mph
x E 0
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
Yaw Angle
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
x E 0
time



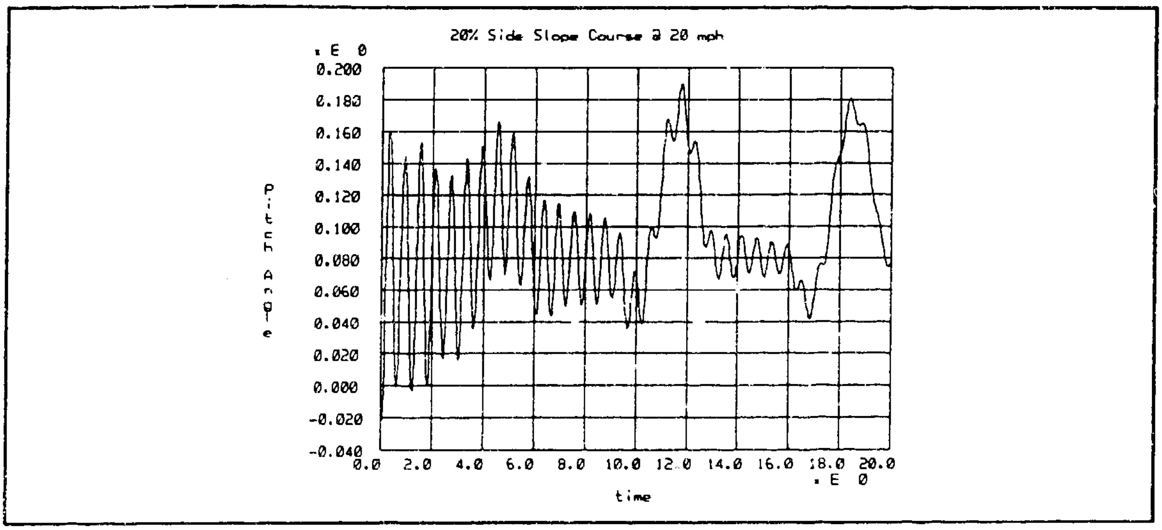
20% Alternating Side Slope Course @ 10 mph
* E 0
Pitch Angle
time
* E 0

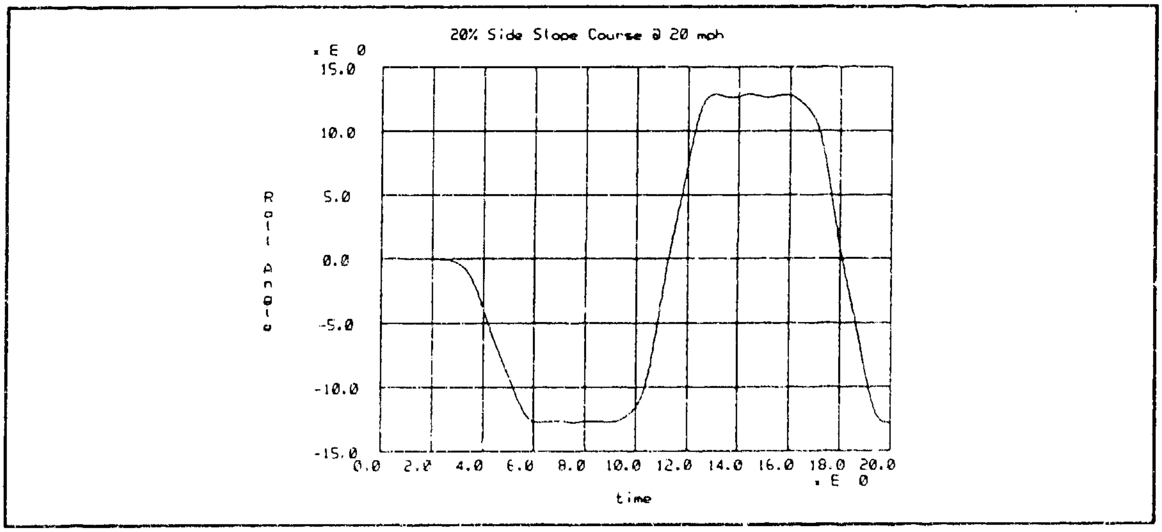


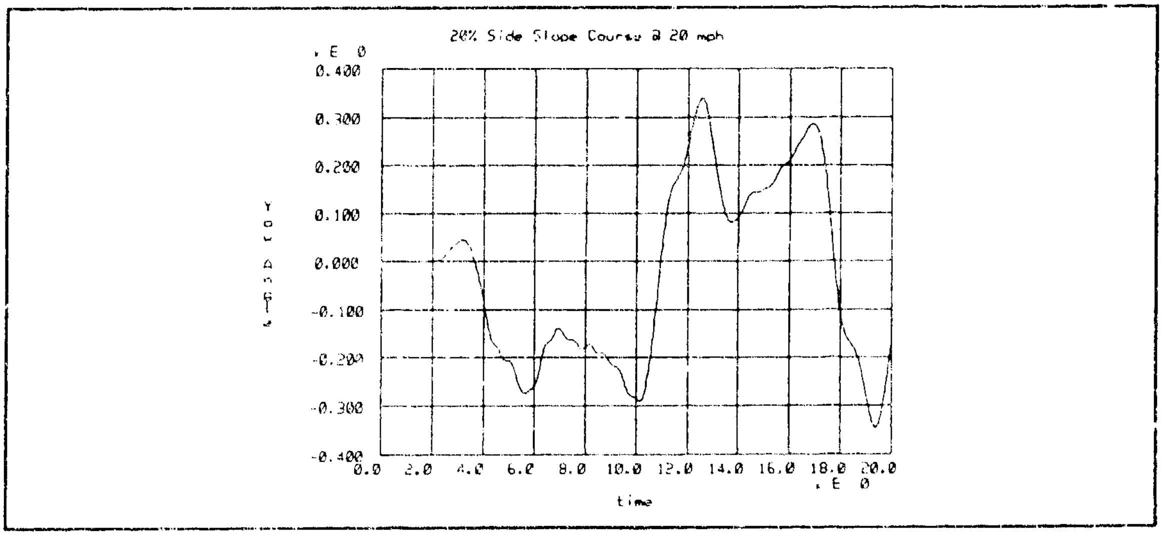
20% Alternating Side Slope Course @ 10 mph
* E 0
Roll Angle
time
* E 0

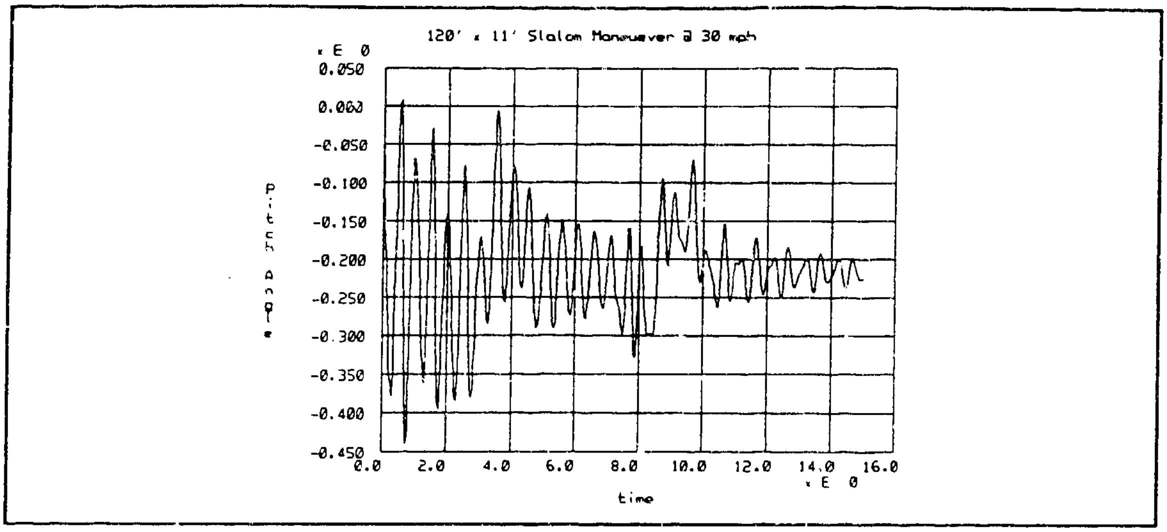


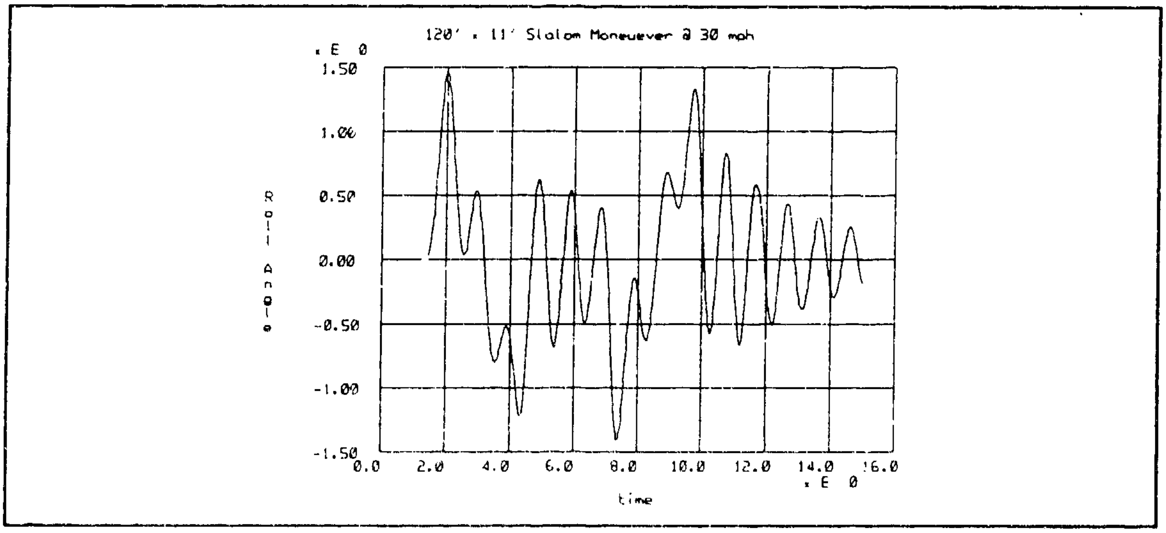
20% Alternating Side Slope Course @ 10 mph
* E 0
Yaw Angle
time
* E 0

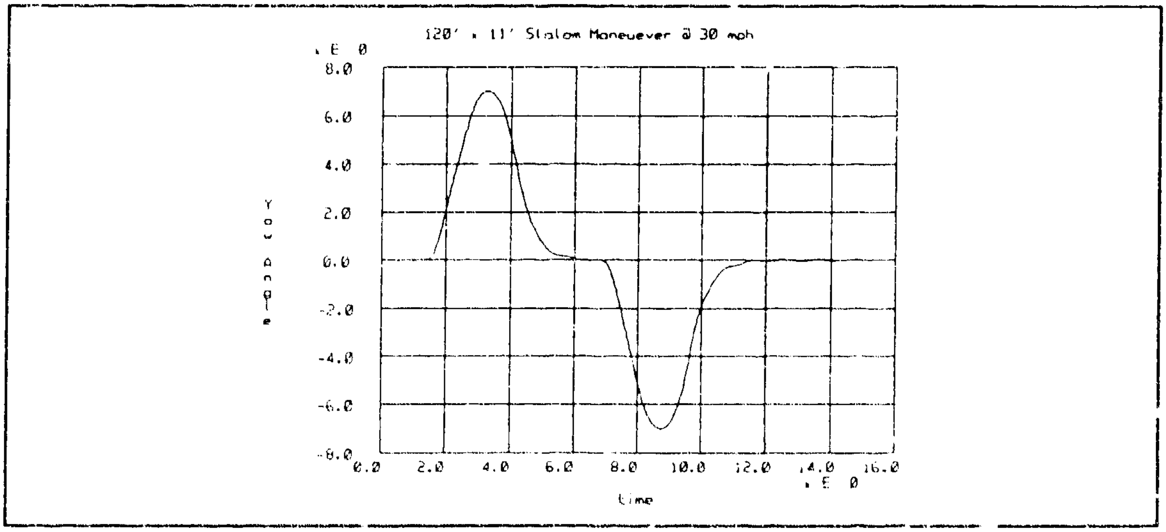

20% Side Slope Course @ 20 mph
* E 0
0.200
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
-0.020
-0.040
Pitch Angle
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0
* E 0
time

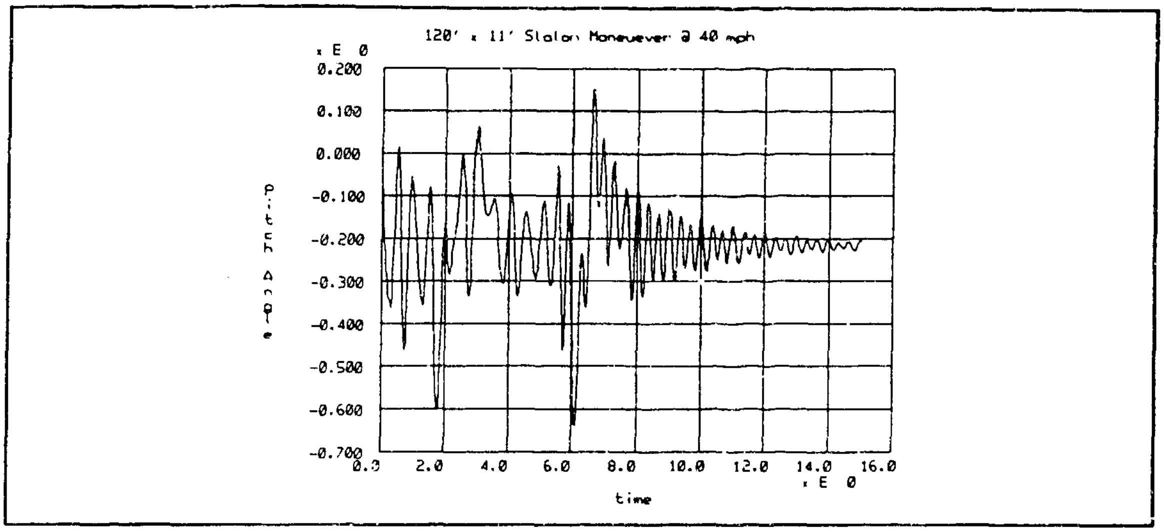

20% Side Slope Course @ 20 mph
* E 0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
Roll Angle
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0
* E 0
time

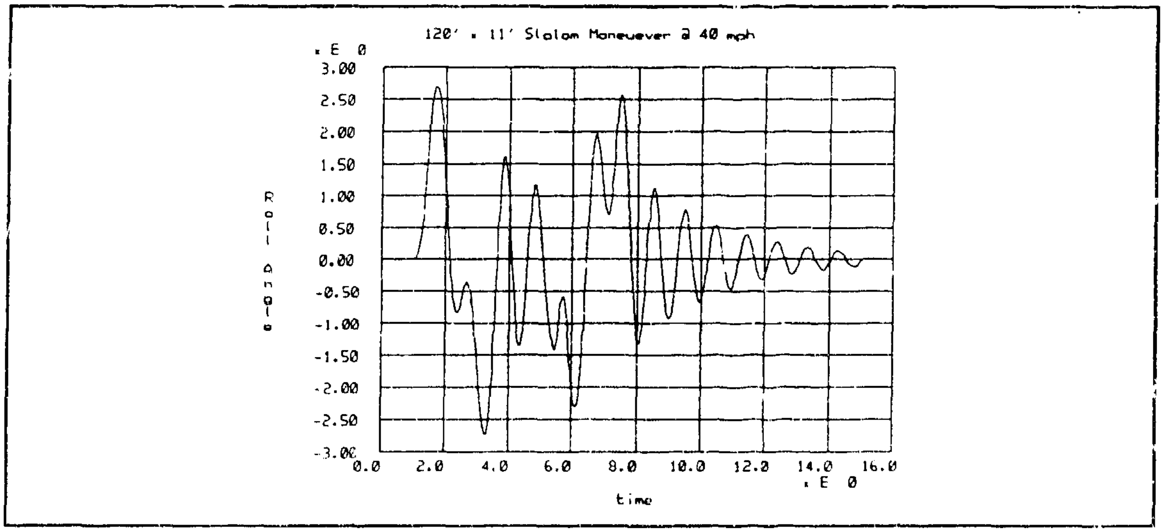

20% Side Slope Course @ 20 mph
* E 0
0.400
0.300
0.200
0.100
0.000
-0.100
-0.200
-0.300
-0.400
Yaw Angle
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0
* E 0
time

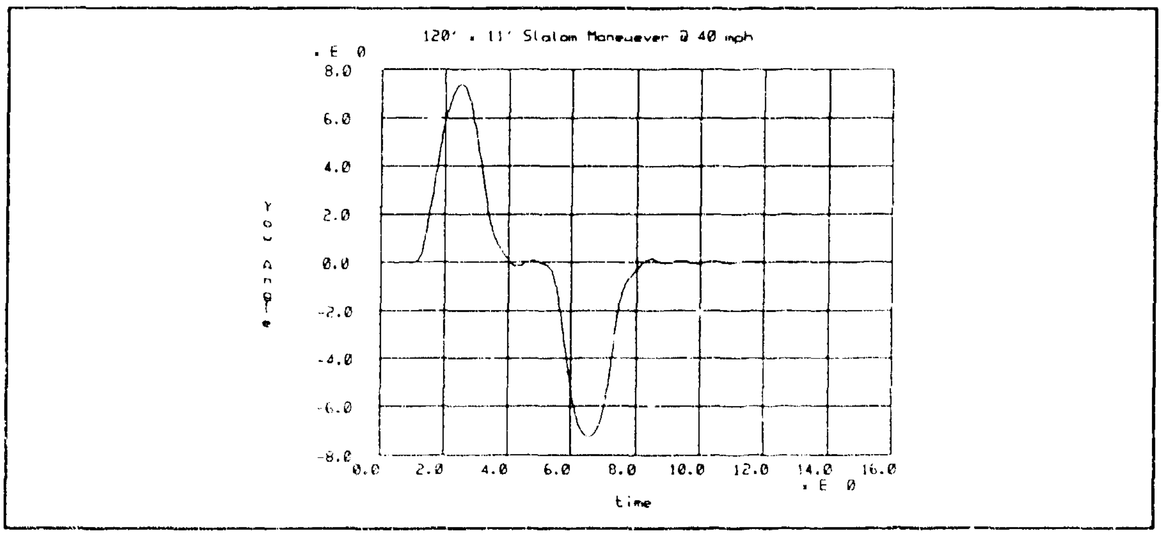

120' x 11' Slalom Maneuever @ 30 mph
x E 0
0.050
0.000
-0.050
-0.100
-0.150
-0.200
-0.250
-0.300
-0.350
-0.400
-0.450
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
x E 0
time

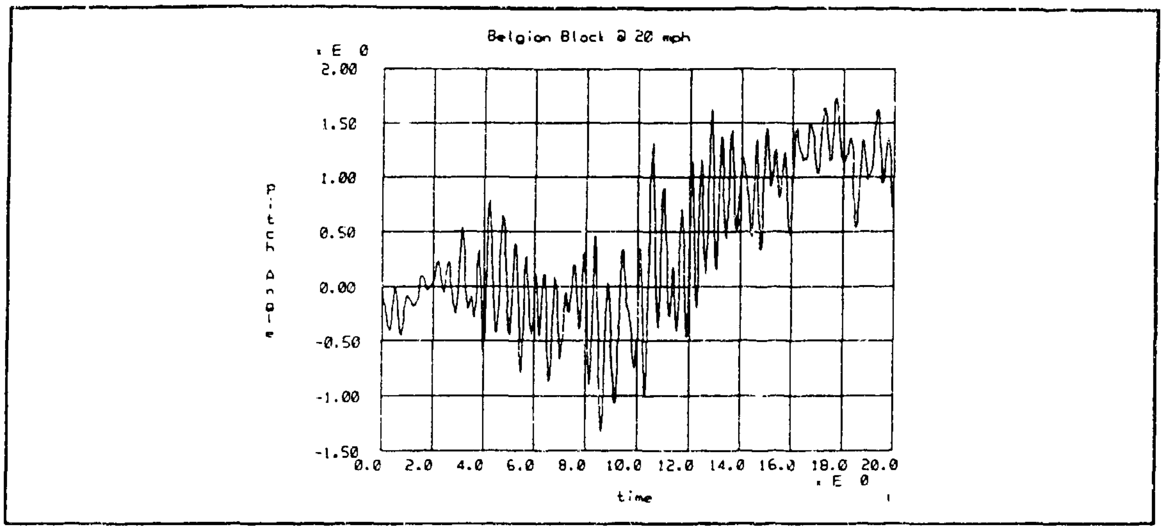

120' x 11' Slalom Maneuever @ 30 mph
x E 0
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
Roll Angle
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
x E 0
time

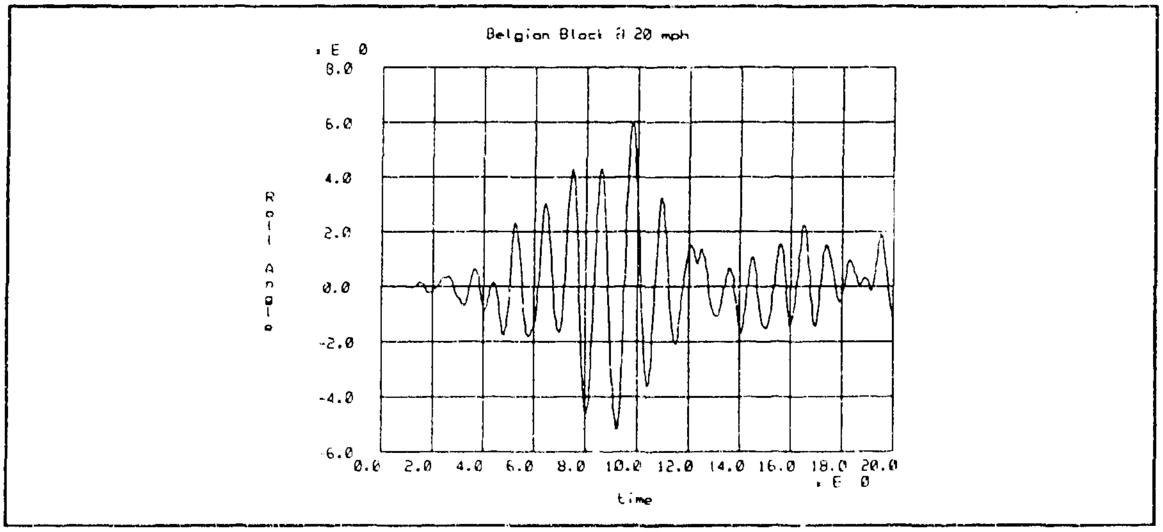

120' x 11' Slalom Maneuever @ 30 mph
x E 0
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
Yaw Angle
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
x E 0
time

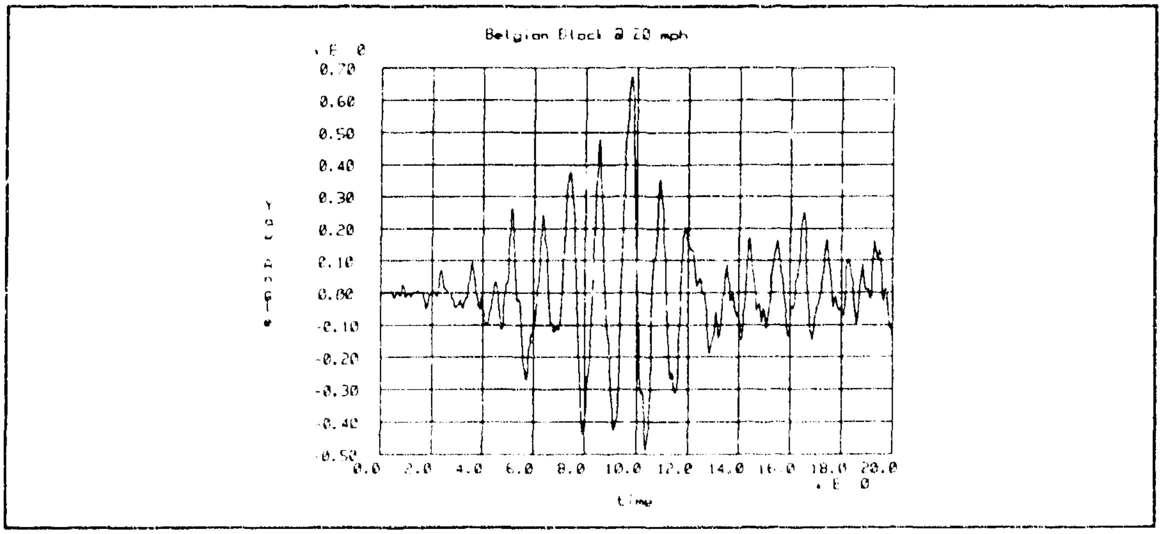

120' x 11' Slalom Maneuever @ 40 mph
x E 0
0.200
0.100
0.000
-0.100
-0.200
-0.300
-0.400
-0.500
-0.600
-0.700
Pitch Angle
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
x E 0
time

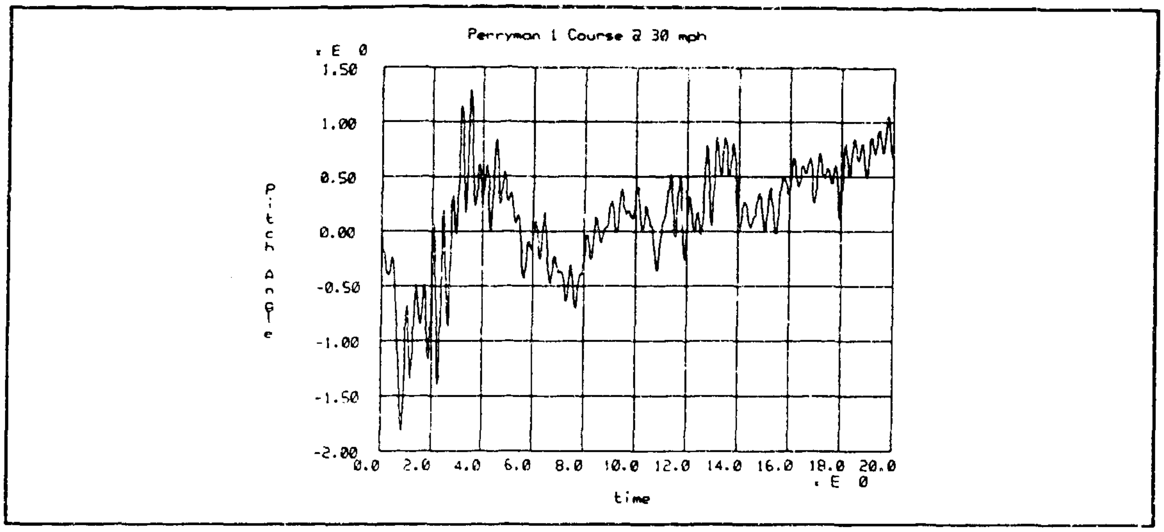

120' x 11' Slalom Maneuever @ 40 mph
x E 0
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
Roll Angle
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
x E 0
time

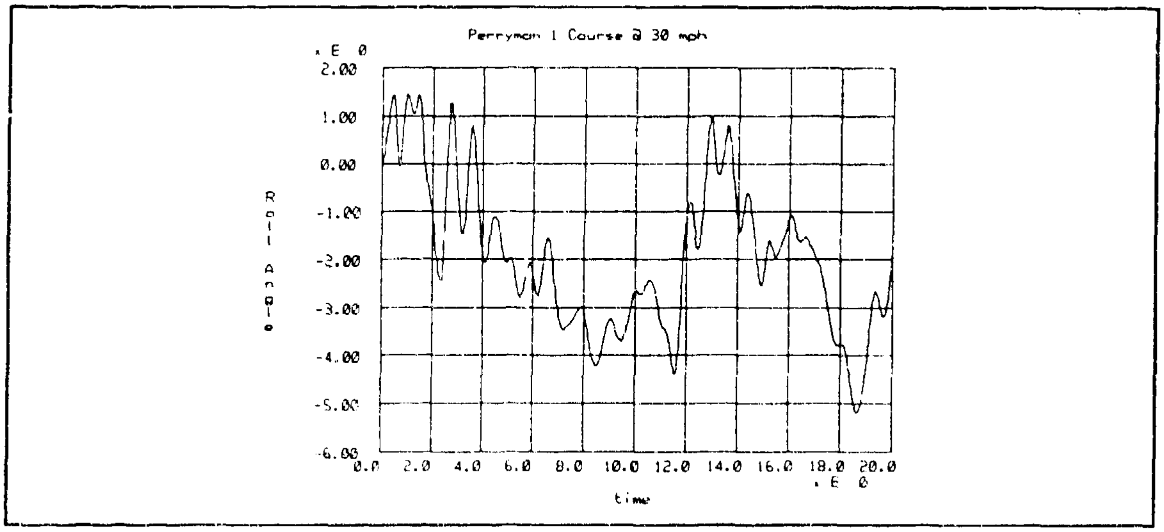

120' x 11' Slalom Maneuever @ 40 mph
x E 0
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
Yaw Angle
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
x E 0
time

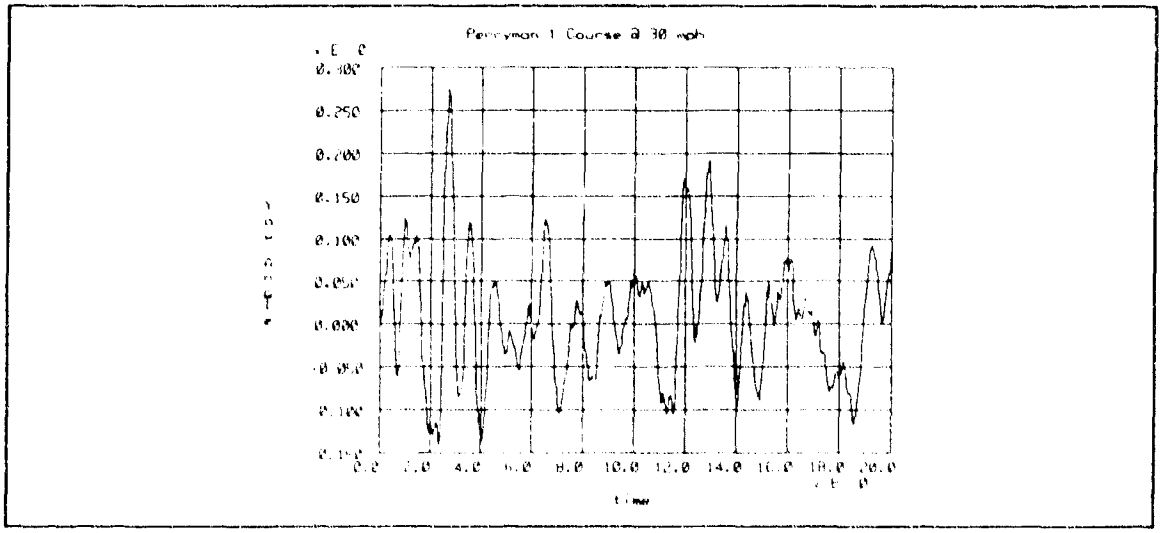

Belgion Block @ 20 mph
pitch Angle
time

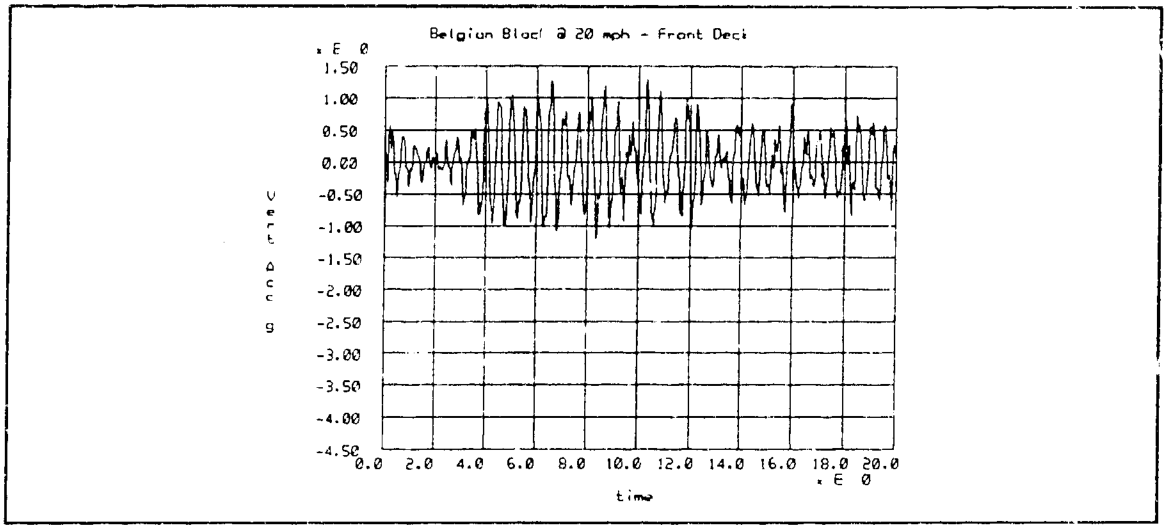

Belgion Block @ 20 mph
Roll Angle
time

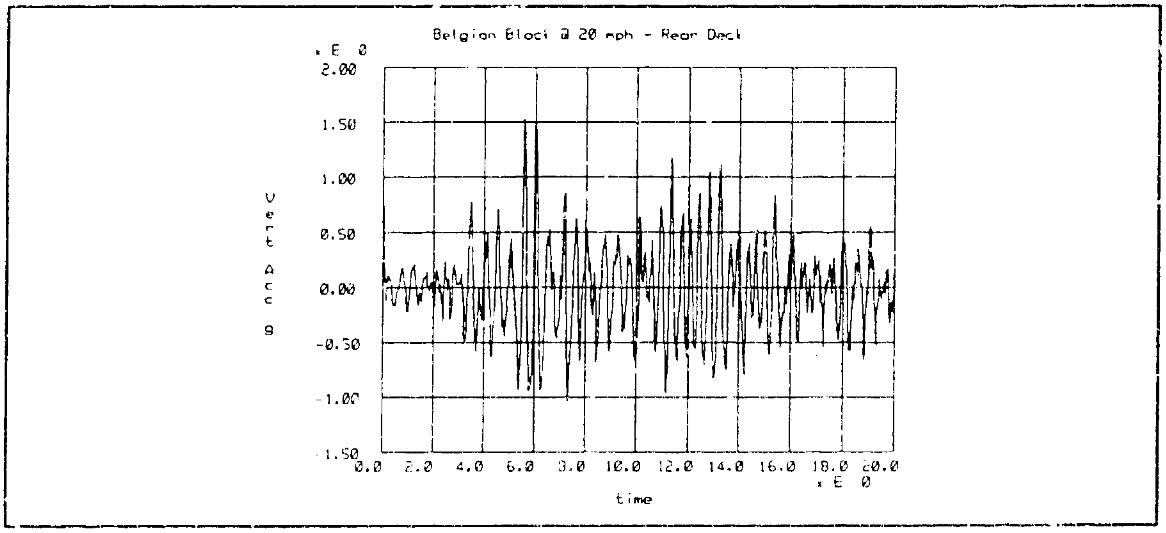

Belgion Block @ 20 mph
time

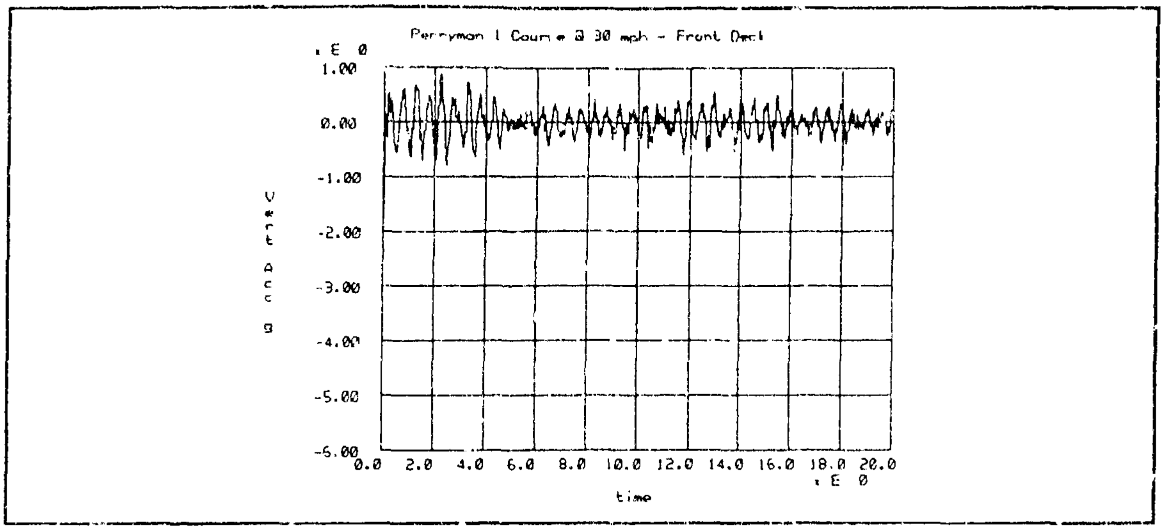

Perryman 1 Course @ 30 mph
* E 0
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
Pitch Angle
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0
* E 0
time

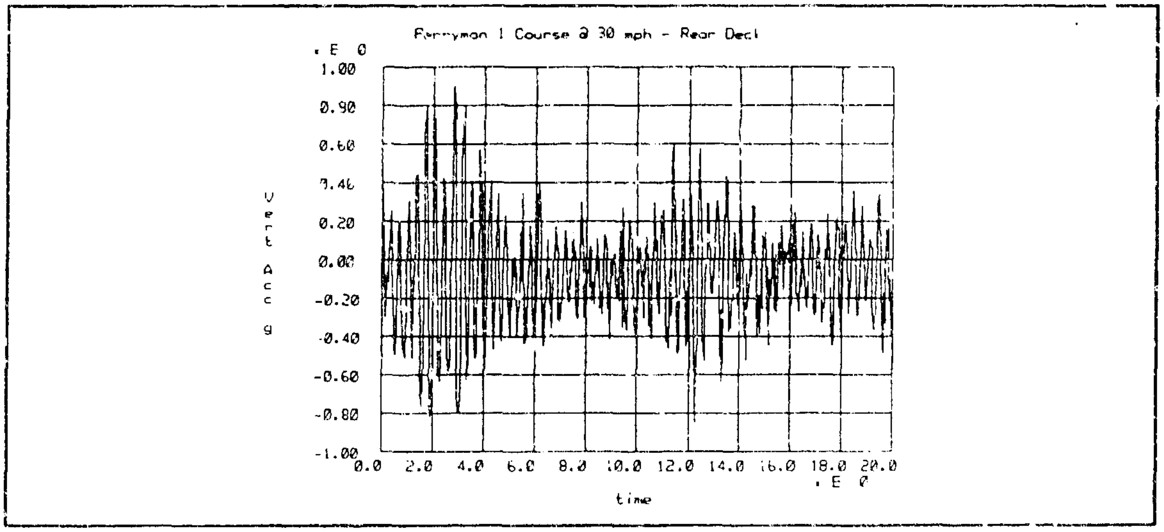

Perryman 1 Course @ 30 mph
* E 0
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
Roll Angle
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0
* E 0
time


Perryman 1 Course @ 30 mph
time


Belgian Block @ 20 mph - Front Deck
x E 0
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
-3.50
-4.00
-4.50
Vert Acc g
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0
x E 0
time


Belgian Block @ 20 mph - Rear Deck
x E 0
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
Vert Acc g
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0
x E 0
time


Perryman 1 Course @ 30 mph - Front Deck
Vert Acc g
time


Perryman 1 Course @ 30 mph - Rear Deck
Vert Acc g
time

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